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The Kent Incorporated Society for Promoting Experiments in Horticulture

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ANNUAL REPORT

(THIRTY-FIRST YEAR)

1943

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1943 to 31st December, 1943

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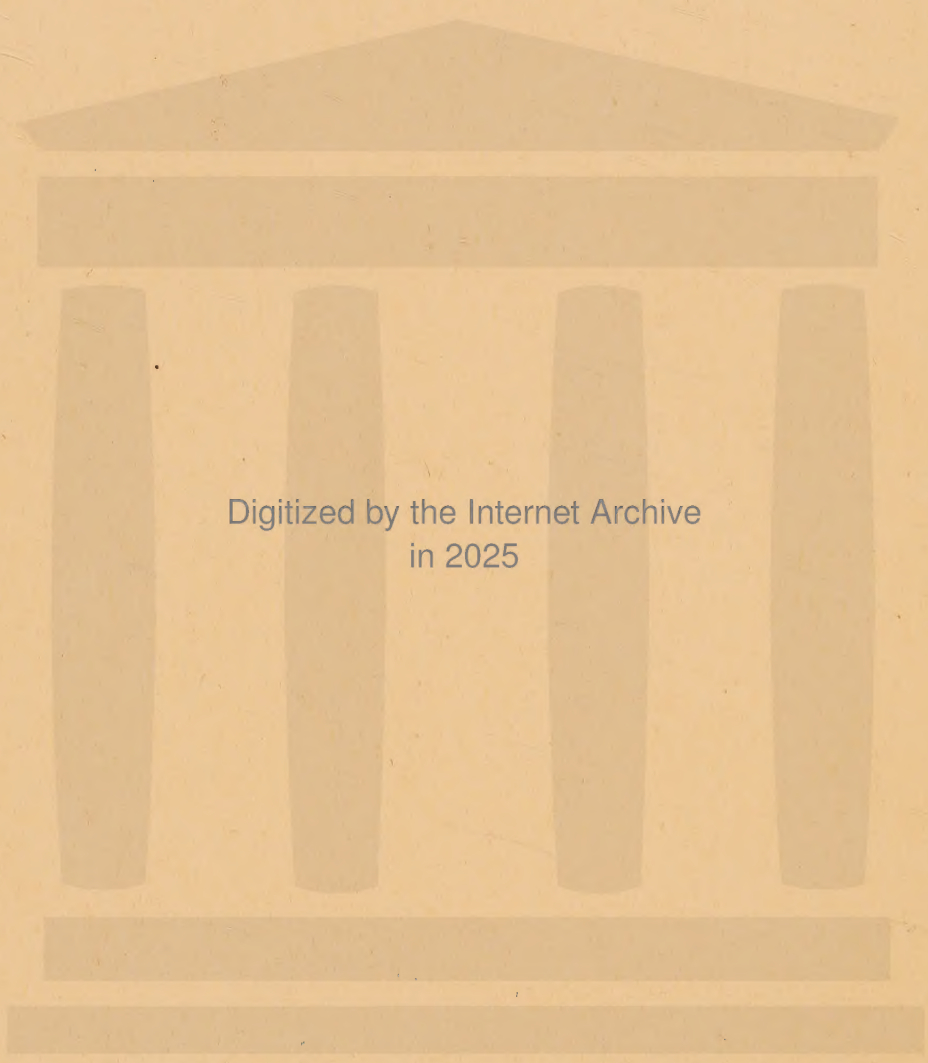

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THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

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EDITORIAL

Again there has been some delay in the publication of our Annual Report, but it has enabled us to indicate the more recent changes in the Staff. It will be seen that owing to the regrouping of certain members of the Staff the Section Insecticides and Fungicides is now replaced by one for Plant Protective Chemistry.

A new feature has been introduced at the request of overseas readers of the Report. In Section I, The Experimental Farm, we have tried to define the various measures used for fruit in this country. It should be noted, however, that the weights are of necessity only approximate, for the bushel, half sieve, etc., are really measures of capacity, and contain not only different weights for different fruits, but also vary from variety to variety within the same kind of fruit.

Dr. Montgomery has helped in assembling Section IV. Heads of Sections are responsible for the Sectional Reports and Dr. Wormald has again undertaken the general editorship.

R. G. Hatton.

July 1944.

Section I

THE EXPERIMENTAL FARM

Contributions from J. AMOS, F. H. BEARD, D. H. HAMMOND, T. N. HOBLYN and H. M. HUGHES

Following a year in which record crops of most fruits were harvested, 1943 might have been expected to be an " off " year. Nevertheless, on the whole, the yields were not much inferior to those of 1942, for although some varieties cropped lightly, the deficiency was to a large extent made up by the better cropping of others. The season will be remembered as one of the earliest throughout on record. After a mild winter the blossoming season was about a fortnight earlier than the average and, with the exception of small fruits and late flowering apples, was completed by the end of April. The year 1943 differed from other early seasons, however, in the weather during blossoming and afterwards. No frosts were recorded in the screen after the first week in March and the few ground frosts in April did no damage. May was an exceptionally warm and sunny month so that strawberry picking started on 1st June, while the subsequent harvesting season continued to be an early one right up to the end. Early apples and plums were being picked by 15th July, Worcester Pearmain apples by 12th August, Bramley's Seedling by 15th September, and all picking finished by the first week in October.

Experimental Orchards.—Top Fruits.—*Apples.*—The total crop off 50 acres was 10,800 bushels (a bushel of apples weighs approximately 40 pounds). This was some 2,700 bushels less than in 1942, the deficiency being largely due to the light crops of the two principal culinary apples, Bramley's Seedling (about 2½ bushels per tree) and Lane's Prince Albert (1 bushel per tree). On the other hand most varieties of dessert apple cropped comparatively heavily. Miller's Seedling (125 trees) gave over 3 bushels per tree. Worcester Pearmain with a total crop of 3,150 bushels, gave the heaviest yield of this variety for the whole farm yet recorded. On the rootstock trial this variety has now kept up an average of 3 bushels per tree, or nearly 600 bushels per acre for five consecutive seasons. Cox's Orange Pippin nearly equalled the good crop of the previous year on the whole, though this was largely due to increased crops from some of the younger trees that had not cropped previously. The 16-year-old half standard Allington Pippins on vigorous rootstocks yielded just under 5 bushels per tree for the second year running, and some 50 trees of Laxton's Superb, top- and frameworked on half standard Newton Wonder in 1935, gave over 4 bushels per tree. Barnack Beauty, after a very heavy crop in 1942, had an " off " year.

Pears.—The 7 acres of mixed varieties (1,700 trees) yielded some 2,360 bushels (a bushel of pears weighs approximately 48 pounds). This is the fourth year since 1939 in which the yield has been over 2,000 bushels—the average for the five years being some 270 bushels per acre. A note on the cropping of pears during the last twenty years appears in Part IV of this report. As shown there, this five-year period must be considered exceptionally good. With the exception of Conference (360 bushels from 270 trees), most varieties yielded well up to the 1942 standard. The year was noteworthy for the comparatively good yields from some of the shyer cropping varieties such as Pitmaston Duchess and Doyenne du Comice.

Plums.—For the second year in succession the plum crop was a good one—some 6,130 halves being harvested from 14½ acres (a half sieve of plums weighs 28 lb.). This was despite the fact that certain varieties were in an " off " year. The outstanding variety in 1943 was Victoria. Some 340 trees of this variety, aged up to twenty-one years, many of the older trees of which are now affected with Silver Leaf, averaged nearly 5 halves per tree, while on Deadman Field trees from 6 to 8 years old bore their first crop of 2 halves per tree. Czar, most of the remaining trees of which are in a windbreak, also cropped well. The Cherry Plum windbreaks on the other hand blossomed very lightly and bore a very small crop, though this was of very good quality. The 3 acres of Giant Prune on Deadman Field bore a comparatively light crop, though here again the quality was good. In the five years since 1939 this variety has cropped very regularly averaging over 9 tons per acre or 4½ half-sieves per tree annually. The trees have now been grubbed to make room for a young collection of gages interplanted among them.

Cherries.—After the exceptionally heavy crop in the previous year, the 140 trees of Kentish Red had made little new extension growth and only bore an average crop of 295 halves (a half-sieve of cherries weighs 24 lb.). The number of trees of Morello was reduced owing to the grubbing of some 80 trees on Newgates. The rootstock trials of this variety on Egham Field, however, cropped nearly as heavily as in the previous year, 437 halves from 240 trees. The 12 acres of sweet cherries in the

variety collection and rootstock trials, of varying ages up to 16 years old, which bore their first crop in 1942, produced 850 halves. The interplanted plums on about 4 acres were grubbed at the end of the season.

Small Fruits. –At the end of 1942 all the large areas of small fruits were grubbed. In this year, therefore, we had only small areas under various experiments.

The cropping of these trials is more appropriately discussed in relation to their experimental results. The land freed as a result of these grubbings will be used for arable crops in preparation for further experiments in due course. J.A., T.N.H.

Experimental Nurseries.—There were some 36 acres occupied by experimental nurseries during 1943, of which 17 acres were stool-beds and 8 acres strawberries. Various experimental tree nurseries occupied some 2½ acres, while black currant, Myrobolan B and Marianna cuttings, and the raspberry and loganberry propagation beds, accounted for the remaining 8½ acres.

The new 10 acre stool-bed was completed early in 1943 with the planting of the last 5 acres, and we shall be taking a crop from the whole of the 10 acres for the first time at the end of 1944. Although some of the stools and layers in a stool-bed planted in 1928 have become too old for economical earthing, it was felt that they should not be grubbed until the new stool-bed came into production, owing to the shortage of rootstocks throughout the country. Some 790,000 rootstocks were produced and distributed during the winter of 1943-4. This was considerably less than the previous year, as it did not include any bedded rootstocks, these having been sold to the trade the previous season as second sized one-year layers.

The acre of new and established varieties of raspberries laid down for propagation last year yielded some 15,000 canes. A further 3 acres were planted for propagation at the end of 1943.

The half-acre of clonal loganberries planted in 1942-3 to complete the acre required for the nuclear stock scheme gave its first crop in 1943 ; this was not as great as might have been expected owing to the parent plants being badly damaged by wind at the beginning of 1943. However, some 5,400 rooted tips were produced and bedded up for a further year.

The 8 acres of strawberries, Royal Sovereign M40, planted for runner production, were badly affected by the dry weather in the spring, and a severe attack of wireworm. The resulting crop of runners was very disappointing, only 211,000 runners being produced. These, together with the 9·8 acres of daughter nurseries, produced 1,068,620 plants. Some 532,000 Huxley plants were produced by the five daughter nurseries during 1943-4.

Some 25,000 2-year blackcurrant bushes were produced and dispatched during 1943-4, and 24,500 1-year bushes were retained in our nurseries.

On the whole the bushes, trees and rootstocks produced were well up to standard.

The extension of the nuclear stocks of small fruits and the rapid extension of our stool-bed area has entailed much extra work. Fortunately the weather remained open during the autumn and winter of 1943-4, and the work of getting the rootstocks removed from the stools, trimmed, graded and packed was not interrupted. Thus it was possible to handle large quantities of material with the limited labour available.

It is interesting to note that some 125,000 pegs were used last spring for layering in the nurseries. The making of these pegs makes a great call on labour, when the various operations required to produce pegs are considered. Firstly the poles have to be sawn into 12-15 inch lengths, then split into two to four according to size, sharpened, and then a 2-inch wire nail driven about ⅓ of its length into the peg about 1 inch from the top of the unsharpened end. D.H.H.

Hops.—Acreage 9¾ acres. 8¾ acres New Varieties and Fuggle in Egham and Church Field gardens, and 1 acre of recently planted Goldings at Bradbourne. The seedling OV7 (just under ½ acre) has been replaced by the best of the clonal strains of Fuggle so far tested, and these will be used to provide a nucleus of nettlehead free, mosaic tolerant stock for eventual distribution to growers. At the present time all Fuggle sets are required for pathological trials. Twenty-one short rows of seedlings have been replaced by new selections from Wye. Diseases and insect pests were not unduly troublesome, though there was some late " Aphis blight " on a few varieties. Drought conditions caused a reduction in the yield of some late varieties, particularly the first generation seedlings from the New Mexican hop, several of which were almost entire failures. The behaviour of this type of hop gives a fairly good example of the need for carrying out cropping trials over a long period of years as, until the present dry seasons, they were amongst the heaviest croppers. Though the young plantings of Brewer's Gold and Bullion Hop showed symptoms of drought injury, the mature rows of these varieties cropped at the rate of over 25 cwt. per acre.

Our total growth was about 5¾ tons which can be considered satisfactory in view of the dry season and the fact that much of the acreage was immature (3 acres). Of 120 varieties picked and dried separately, 11 gave crops equal to that of the previous year, 44 gave heavier yields, 51 gave lighter yields, whilst 14 had not previously been harvested separately. Once again certain growths

were bought by a well-known firm of brewers and valued on a P.V. (10α) basis. The following table gives the valuation of the principal growths for the seasons 1942 and 1943. F.H.B.

Variety.	1942. Ordinary Valuation.	1942. Valuation on P.V. Basis (10α).	1943. Ordinary Valuation.	1943. Valuation on P.V. Basis (10α).
	£ s.	£ s.	£ s.	£ s.
Nonsuch Hop (OB53)	—	27 10	—	27 13
OM26, " sport " from Nonsuch Hop	—	—	—	36 0
Brewers' Gold (C9a)	19 0	24 6	19 15	28 12
Bullion Hop (Q43)	19 0	23 18	20 5	28 7
Brewer's Favourite (OP21) ..	18 5	24 16	19 10	22 17
Quality Hop (0063)	18 5	20 17	18 15	24 11
Fillpocket (Z62)	18 5	14 16	17 15	20 19
College Cluster (N15 bis)	—	18 15	—	19 14
Brewer's Stand-by (HH44) ..	—	26 14	—	24 4
Malling Midseason (BB28)	—	25 10	—	24 15
Fuggle	17 15	16 8 to 17 12	17 15	—
Mixed Growths	17 0 to 17 5	12 12 to 15 18	15 5 to 18 10	

Arable Crops.—As noted in last year's Report, the remaining 100 acres of Park Farm, Bradbourne, were taken over at Michaelmas, 1942. This land, together with other areas not yet planted or from which experimental plantings have been grubbed, will be maintained under arable crops in preparation for future experiments. During 1943 we were thus able to devote some 172 acres to primary food crops. This acreage is rather more than will usually be available for arable crops, owing to the clearing of about 12 acres of soft fruit on Newgates and Deadman fields and the absence of any substantial new fruit plantings. It is expected, however, that there will normally be about 160 acres under arable crops and this area will be run as a 4-course rotation—wheat, barley, seeds and potatoes. In order to clean the land, put back much needed humus and build up a store of organic matter, it is proposed to plough in one year leys. This will be supplemented for a number of years by maintaining a yard of store cattle. For this purpose part of the seeds will be made into hay, and root and green crops grown. This system will also enable us to use up our straw. During 1942-3 a yard of 24 head of cattle was maintained, which used up an accumulated stock of straw and produced some 400 tons of well-made manure. The cropping of the above area was as follows :

Potatoes.—Forty acres of Majestic, half from a Scotch source and half from an Irish source, averaged some 8 tons per acre.

Cereals.—Forty-two acres of Als wheat yielded just under 6 quarters to the acre. Thirty-two acres of Plumage Archer barley were sown in late January ; 22 acres of this grew well and produced 6 quarters to the acre ; 10 acres, however, made a poor stand and only gave 1 quarter to the acre.

Ten acres of spring sown Victory oats were badly checked by drought and only yielded just over 5 quarters to the acre.

Thirty acres of the area under barley and oats were undersown with seeds in spring.

Seeds Hay.—Thirty-three acres gave a fairly heavy first cut. A light second cut was obtained from two-thirds of the area, the remainder being ploughed in for nursery crops.

Root and Green Crops.—Ten acres were devoted to root and green crops for cattle feed. This included 3 acres each of mangold, marrowstem kale and cabbage and 1 acre of swedes. Two acres each of savoys and spring cabbage were grown for market. J.A.

Tomatoes.—A large part of the Bradbourne walled gardens, about 1 acre (12,000 plants), was cropped with outdoor tomatoes. An account of the variety trial (3,600 plants), which formed a part of the planting, is given in Part III of this Report. The remainder of the area was mainly planted to Market King. A total of 8½ tons of good quality ripe fruit was harvested and a further 8 tons of green fruit were cleared at the end of September and sold for ripening under glass. About ½ ton of split fruit was unfit for marketing and was composted. Routine copper lime dusts were applied for the prevention of Blight, but the season was generally Blight free and the disease only appeared on a few plants at the end of the season. H.M.H.

Routine Spraying Programme. The programme given in the 1942 spray calendar was again followed with slight modifications as necessary.

Most apples and all pears and cherries received a tar oil winter wash. Spraying commenced in mid-December, but was delayed by inclement weather and not completed until the end of January. The winter tar oil on apples was followed by petroleum oil emulsion (6% actual oil) against Capsid and Red Spider during the last weeks in February.

All plums and the apples on Kiln field received a single D.N.C. petroleum wash during the first ten days of February instead of the tar oil and petroleum as above. No appreciable damage from either of the oil sprays was noticed.

Only one pre-blossom spray was applied to pears, lime-sulphur 1½ gall. + arsenate of lead 2 lb. for caterpillar, followed by one post-blossom application of Bordeaux mixture (4-6-100).

All sweet cherries were sprayed pre-blossom (9th April) with Bordeaux mixture (6-9-100) for Bacterial Canker. All apples received the green bud spray of 2½% lime-sulphur. No lead arsenate was included as it was thought that the amount of caterpillar did not warrant its use. However, on many plots the damage was far worse than was anticipated and in some cases necessitated an additional spraying with lead arsenate only.

Owing to an early and short pre-blossom period it was not possible to give the usual two pre-blossom sprays to all plots of apples. Where the second application was made, 1% lime-sulphur was applied. The petal-fall spray of lime-sulphur plus nicotine was not applied rapidly enough to ensure a complete control of Sawfly and many fruits were scarred as a result. Owing to the appearance of Scab on many of the young fruits and the risk of fruit drop at this stage from lime-sulphur, the following spray was substituted—lime-sulphur ½% + colloidal sulphur 3 lb. per 100 gall. + a spreader—on Bramley, Cox and Worcester as the second post-blossom spray. However, where this spray was used, a very heavy fruit drop followed, but this may have been due in part to hot dry conditions.

Red Spider was very severe on many plots and was most noticeable where the second post-blossom sulphur spray was omitted. Although lead arsenate was applied against Codling during the week 17th to 24th June, this proved of little use in this early season and there was much damaged fruit. These Codling infested fruits were later attacked by Brown Rot and acted as centres of infection for the spread of the disease to other fruits.

Strawberries, both layer and fruiting beds, received routine dustings with flowers of sulphur against Mildew. The larger runner beds were treated with vaporized nicotine for the control of strawberry aphis on 24th August, using the machine specially built for the purpose. The smaller plots, for which it was not possible to use the vaporizing machine, were sprayed with nicotine.

Both raspberries and loganberries received one application of derris against beetle. Whilst this was effective on raspberries, the later loganberry fruits contained many maggots, showing the need for a second spray.

Hops were not troubled by aphis very early in the season, but were sprayed on 9th June with 8 oz. nicotine + a spreader, to which 1% lime-sulphur was added against red spider. Both pests were controlled successfully. Two Bordeaux mixture sprayings were given and to each nicotine was added. With very few exceptions these sprays kept the crop free from Downy Mildew. J.A.

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By R. G. HATTON and W. S. ROGERS

A.—Tree Fruits.—Rootstocks.—The records essential for continuing the complete life history of the field rootstock trials of apples, pears, plums and cherries have been maintained. Some further thinning out of trees in the older trials became necessary and afforded opportunity for obtaining trunk and branch weights. The cumulative records of this work have been brought up to date and have provided new information as to which rootstocks, and even what relative quantities of each, should be propagated and made available for post-war planting. This information is now eagerly being sought by the Nursery Trade. This summary has also made possible the publication of the actual yields of fruit, over 23 years, of four experimental plantations (E192. See also II).

The first considerable crop of rooted layers of 20 of the apple rootstocks immune from Woolly Aphis has been raised for a full scale nursery and field trial. A preliminary trial of Lane's Prince Albert worked on these has been planted out. Another trial of Cox's Orange Pippin on 18 selected rootstocks of outstanding promise, raised from crosses between Malling rootstocks, has been planted. A paper dealing with the early behaviour of Cox's Orange Pippin and Lane's Prince Albert on 38 of these rootstocks has been published (E190).

The anatomical work, which has given results of immediate value in rootstock selection and identification and also promises to throw more light on the causes of rootstock effect, has been continued. Further studies with apple trees have been made of (1) the correlation between rootstock structure and the vigour and cropping of the scion, (2) the reciprocal effect of scion on rootstock, and (3) methods of identification of rootstocks by their anatomical structure. Preliminary studies of the anatomical structure of plum rootstocks have been developed. Several new or improved methods have been tried.

A paper on the standardization of horticultural material, with special reference to rootstocks has been published. As part of this work of standardization, descriptions of the botanical characters of apple rootstocks M. I to XVI, W. XVII and XVIII and M. XIX to XXIV have been revised and brought up to date in the light of contributions from other research workers. Detailed identification keys for use in summer as well as in winter, and shorter forms specially adapted for practical inspection purposes, have been prepared for publication. Similar work for plum, quince and cherry rootstocks has been in progress. Certain ratios (such as length : breadth of leaf) have been found useful in some of these identification keys, and special diagrams which make possible the rapid calculation of these ratios, have been designed. Since such diagrams appear to have a number of other uses in horticulture, a paper on their design and use is being prepared.

For a second year in succession sweet cherry trials cropped heavily. There can no longer be any doubt that different clonal Mazzard rootstocks, besides influencing vigour, have different influences on cropping (independently of tree size), fruit size, and time of blossoming and ripening. It is also probable that, as with other tree fruits, certain varieties of both sweet and acid cherries will show rootstock preferences.

An account of a trial of various stem-builder varieties of plum to form a resistant stem and crotch for the variety Victoria, which is highly susceptible to Bacterial Canker caused by *Pseudomonas mors-prunorum* Worm., has been published (C190). Differences were observed in the vigour and cropping of Victoria with different stems all on Myrobolan B rootstock ; with President stems the combination of the three appeared to be incompatible. (See also V. A.)

Propagation.—Collections of apple, pear, quince, plum and cherry rootstocks were maintained and examined for propagation qualities.

Amongst a preliminary selection of fifty-five apple rootstocks, immune from Woolly Aphis, there are marked differences in rooting qualities and habit of growth. Twenty have been selected for the production of trees for extended field trials. Some 700 rootstocks, the 1942 crop of layers from the whole 55, were budded with McIntosh Red and Cox's Orange Pippin as a preliminary test of compatibility with these varieties.

Stool-beds of 18 apple rootstocks, not bred for immunity from Woolly Aphis, but having outstanding pomological qualities (see above), were extended. Ninety-five clones of quinces collected

from Europe and South America were budded with Williams' Bon Chrétien pear, alongside the original East Malling selections, to determine their compatibility with this variety which is at least partially incompatible with most quinces. Cherry rootstocks, selected for possible dwarfing qualities, were budded with sweet varieties. Bud " take " has so far been disappointing but sufficient trees are now available for a preliminary field trial as bush trees.

In view of the general shortage of rootstocks special emphasis is being placed on the most rapid methods of propagation.

Numerous hardwood-, softwood- and root-cutting trials were planted in different situations. The importance of the source of cutting material has been confirmed. A trial of the effect of manurial treatment of the parent upon the quality of cuttings has been started on a mature hedge of the plum rootstock Myrobolan B. Trials with softwood cuttings have also shown the importance of the condition of the material used as cuttings. Rooting was aided by preliminary treatment with synthetic growth substances. A batch of selected pear rootstocks, rooted by the aid of indolyl butyric acid, has been planted in the open, where records of subsequent growth will be made.

Trials with root cuttings of apple, pear and cherry have indicated the possibility of this method for the propagation of rootstocks which do not respond readily to other methods. The extension of this technique is limited by the present lack of suitable youthful roots. The apple rootstock Crab C, the Mazzard F12/1 and a selected acid cherry have rooted comparatively well in preliminary trials. (See also III.)

A test for protecting rootstocks against parasitic soil fungi by dipping in Bordeaux mixture was undertaken in collaboration with the Pathology Section, in connection with a wilting of plum shoots in layer rows. (See V. A.)

A bulletin, " Raising Rootstocks ", describing methods of rootstock propagation was published (E191.)

Re-working, Frameworking, etc.—Two papers (Eg 26, E202) dealing with the provision of pollinators by frameworking and branch grafting were published.

Cover Cropping. –In the trial of semi-permanent swards below apple trees, further evidence was gained of the importance of a correct adjustment of nitrogen supply to the needs of both trees and grass. Even where severe nitrogen shortage was previously evident, a suitable extra dressing of quickly acting fertilizer has caused a resumption of growth of the trees in a single season.

The turning-in of some grass and clover swards in March with compensating nitrogen had an appreciable effect in increasing growth and cropping of the trees in the same year as the disking-in. In another trial, in which short term swards had previously been turned-in, important and beneficial after-effects were observed, extending to the third year after turning-in. By this time the effects of any check originally caused by the grass had been more than counterbalanced by the increased growth following its turning-in. Differences between the after-effects of different swards were found.

Air temperatures recorded at blossom time over bare soil and permanent grass in the middle of plots 48 ft. wide showed small and non-significant differences at a height of 5 ft. 6 in. from the ground.

A trial of three forms of nitrogenous fertilizer on a mixed grass and clover sward showed that all three forms reduced the amount of clover, compared with that in plots receiving no nitrogen. On the other hand, preliminary trials of a subsoil application of nitrogen showed no check to the clover.

An experiment testing differing times of sowing and spraying annual cover crops, with a view to avoiding spray damage, showed that well established plants, sown early in the autumn, can survive winter conditions and sprays, particularly if the sprays are applied as late as possible in the season. A repetition of the experiment is in progress.

Many soil samples for analysis were taken during the year with a view to determining the effect of cover crops on the soil.

A new cover crop experiment, comparing annual, biennial and perennial cover crops with farmyard manure, artificials and straw manuring was started on a young Cox and Worcester plantation.

Inorganic Fertilizers.—The long term trials of inorganic fertilizers have been maintained Indications of a reduction of interveinal scorch by soil application of magnesium sulphate became apparent for the first time after three annual dressings. The importance of the N:K ratio in this connection was also evident.

Soil Moisture and Irrigation. –Soil moisture records obtained with tensiometers under various cover crops and clean cultivation have given further information on the relative competition between cover crop roots and tree roots in different soil layers. A Growers' Bulletin on " Plants and their water supply " was published (P7).

Pruning. –The light pruning methods carried out in collaboration with the Kent County Horticultural Officers, on the rootstock trial plots on various soil types in the County, have continued to be successful in giving early crops of fruit on vigorous trees. Suitable methods for the later

treatment of such trees are being developed further. The need for comparative experiments as material becomes available is evident. Data on the spur thinning and bud rubbing experiments are being summarized for a report.

In the plum stem-builder trials alluded to above, trees pruned in the spring were smaller and cropped more heavily than those pruned in autumn (C190. See also V. A.).

Varieties and Classification.—*Cherries.*—As the more recently acquired varieties come into cropping, it is becoming apparent that certain pairs of varieties, hitherto thought to be identical, are in fact distinct. This is occurring at least as frequently as the discovery of previously unsuspected synonymy.

Breeding. –Observations have been continued on about 3,000 apple and pear seedlings raised from crosses between many of the best established varieties. Among the apples selected new varieties are being frameworked to older trees or placed on trial in other plantations. In particular, success has been achieved in obtaining apples similar to Worcester Pearmain in appearance, but differing from it in season of fruit maturity. (See p. 34). Studies on the inheritance of many characters in both apples and pears are being continued.

Studies on Pollen Influence on Fruit Size and Drop.—An account of the investigations into the influence of different pollens on the development of the fruit in apples and pears, which have been in progress since 1937, is included in this Report (see p. 31).

B.—Small Fruits.—Classification, Nomenclature and Varieties.—*Raspberries.*—The trial of two named varieties and seven seedlings, planted in December, 1941, yielded its first full crop in 1943. The crop figures of the five most promising seedlings, and of Norfolk Giant, were published, together with brief descriptions of the five seedlings (Esf49).

The opinions expressed at a conference of raspberry growers and processors greatly facilitated the choice of six seedlings for further propagation. Every available cane of these six has been planted in new cane nurseries. In addition, a smaller cane nursery of several more recently selected seedlings has been planted to provide material for further cropping trials. This includes one seedling of which a short row produced in 1943 a crop equivalent to about 5 tons per acre, the heaviest ever recorded at East Malling. Another appears to be the earliest ripening seedling of any value so far obtained.

Black Currants.—Material was raised for a new variety trial, comparing old established varieties with some of the promising newer ones. Baldwin, Boskoop, Seabrooks, Goliath, Wellington Triple X, Cotswold Cross, Mendip Cross and Westwick Choice are included.

Loganberries and other hybrid berries.—The collection of different berries has been maintained.

Strawberries.—The fruiting trials of " virus free " clones produced good crops in 1943. Sovereign M40 again showed superiority in cropping and vigour over other Sovereign stocks. The performance of M35 in particular fell short by an appreciable margin. Paxton F20 gave rather disappointing results. Further trials of " virus free " susceptible varieties, including M40, M35, King George F7, Paxton F20 and several other Sovereign and Paxton stocks have been planted.

The Huxley strain trial, which includes the interim stocks of the Nuclear Stocks Scheme, showed interesting differences in vigour and blossom production and it should bear its first crop in 1944. A repetition of this trial, with some other promising clones, has been planted. The trial of clonal Oberschlesien and two Tardive stocks showed that one Tardive stock is definitely superior. A further trial including another promising Tardive clone has been planted. Several other promising clones are being worked up for trial. Material for testing the virus status of these new clones and for the routine testing of field samples of the older established clones has been handed over to the Pathology Section. (See V. B.)

To help in the work of strawberry certification, botanical descriptions and an identification key, based on leaf characters only, have been made for the commoner strawberry varieties. A paper on this subject has been prepared. Descriptions (including also flower and fruit characteristics) and a key for a larger number of varieties are being made.

Propagation.—The supervision of the Strawberry Nuclear Stocks Scheme, for the Ministry of Agriculture, has been continued, and expanded to include 13 nurseries and a total of 32 acres. Well over a million runners were produced and distributed. The demand exceeded supplies, and further expansion is planned for 1944, including nurseries distributed over the country from Norfolk to Cornwall. The clone Oberschlesien M42 has been brought into the scheme for the first time.

Propagation beds of nuclear stocks of loganberries and black currants have been maintained, and the area under new seedling raspberries expanded as rapidly as possible, as described above.

Breeding. –*Raspberries.*—Further selections are being made from the raspberry seedlings, as they come into full cropping, as reported above.

Black Currants. –A small number of selected seedlings, which have shown promise of being superior in cropping and other characters to established varieties, are under trial.

Strawberries.—The search for new varieties showing outstanding qualities of fruit size, vigour,

cropping and disease resistance, among seedlings from crosses between existing sorts is being continued. Ten selections are included in a preliminary fruiting trial.

Cultural Measures.—*Loganberries and other hybrid berries.*—Further information has been obtained on (i) the effect of different methods of training the cane on cropping, and (ii) the best combination of training and spray treatment for the control of Cane Spot disease on loganberries and Phenomenal berries. (See also V. B.)

A plantation of loganberries has been established for a manurial and training trial.

Black Currants.—Preparations have been made for planting a 2-acre block of black currants for cultural and manurial trials. One comparison is the use of straw ploughed in before planting, compared with dung and other organic fertilizers.

Irrigation.—A new strawberry trial plot has been planted, designed for irrigation experiments, and for experiments on effect of the straw. (See below.)

Frost Damage Prevention.—Preliminary observations were made on the effect of a straw layer upon the air temperature immediately above it on frosty nights, with a view to determining its possible relation to frost damage to strawberry blossoms. Quite large differences were found, and a preliminary note published (Esf48). (See Summary below.)

A new plot of strawberries, on which different times of strawing can be tested, has been planted.

C.—Nuts.—Observations have been maintained on selected walnut varieties, and these selections are being propagated as rapidly as circumstances permit.

D.—Horticultural Meteorology.—The routine records were maintained. Special studies of air temperature as affected by cultural conditions, such as cover crops or by the strawing of strawberries, were made in connection with the cover cropping and the strawberry trials respectively, as recorded above.

A paper on sun scald of fruits was published (C186). In 1943 isolated cases of sun scald were seen, but no damage so severe as that in 1942 was reported.

Publications during the Year

In Relation to Tree Fruits.

Branch-Grafting for Production of Fruit Tree Pollinators. R. J. Garner. J. Min. Agric. (June, 1943), **50**, 89-92. . (Eg26.)

Examples of inadequate provision for cross pollination of fruit trees still abound. It is suggested here that this can be quickly remedied, without displacing bearing trees, by inserting grafts of pollinator varieties among their branches. Little is known about the actual proportion of pollinators required. When whole trees are used the proportion usually advocated is 1 in 9, which means that the closer the planting the greater the number of pollinators. The author suggests that the orchard should be regarded as a whole, irrespective of the number of trunks, and that a branch of pollinator should be made up for every 30 feet by means of the stub grafting method which is fully described and illustrated. Ten scions are allowed for each branch to be worked, amounting at 30 feet intervals to 500 scions per acre. Suggestions are made as to suitable pollinators and for the care of subsequent growth.

Further Studies on New Varieties of Apple Rootstocks. H. M. Tydeman. J. Pomol., 1943, **20**, 116-26. (E190.)

Details of the behaviour during three years of Cox's Orange Pippin and Lane's Prince Albert apples worked on thirty-eight rootstocks selected from families of crosses between the Malling series of Paradise are given.

All the rootstocks proved compatible with Cox's and Lane's, but there were wide variations in the percentage bud take with Cox's. They showed very great differences in their capacity to induce vigour in both scion varieties, the most vigorous making trees considerably stronger than those on No. XII, and the more dwarfing trees much smaller than those on No. IX. While, in general, there was the usual very close relation between the dwarfing character and early productivity, several of the more vigorous of these new rootstocks gave evidence of being much more precocious than the vigorous rootstocks of the Malling series.

Trees on these rootstocks were found to differ greatly with respect to such characters as anchorage, relative flexibility of shoots, time of autumn defoliation and susceptibility to both marginal and interveinal leaf scorch.

The genetical implications of the results are discussed, and it is suggested that such characters as vigour in these rootstocks are controlled by reduplicated factors which are cumulative in their effects.

It is suggested that certain of these rootstocks may be found in practice to be an improvement on those at present in use in certain definite respects. The lines along which future work will proceed are indicated.

Raising Rootstocks. R. J. GARNER. Rep. E. Malling Res. Sta. for 1942 (1943), 84-90. (E191.)

Fruit Planting Policy with Special Reference to Quality of Material. R. G. HATTON. Rep. E. Malling Res. Sta. for 1942 (1943), 90-3. (E196.)

An Amateur's Fruit Garden. R. G. HATTON. J. Royal Hort. Soc., **68**, 361-74. (E200.)

The considered planning of the Fruit Garden.
The segregation of the appropriate kinds and varieties of fruit. Their protection from birds.
The regular spraying, manuring, pruning and training to meet their particular needs.
The choice of varieties to suit successional needs, primarily for dessert purposes.
The purchase of trees on suitable rootstocks.
The economic utilization of spare wall and fence space.
The avoidance of overcrowding and incompatible under-cropping.

Frameworking for Increased Fruit Production. R. J. GARNER. Occ. Pub. Sci. Hort., 1943, **4**, 63-5. (E202.)

The introduction of pollinator varieties into plantations and orchards by means of frameworking whole trees or single branches is described. Hints on staging practical demonstrations and sources of further information are given.

Bark Splitting of Fruit Trees. W. S. ROGERS. Gdnrs Chron., 1943, **113**, 85. (E204.)

The statement, by a writer in the *Gardeners' Chronicle* of 6th February, 1943, that severe bark splitting of fruit trees may be caused by the application of grease-banding material direct to the trunks of fruit trees is queried. Splitting, such as that described, was observed in January, 1940, following severe frosts on trees, which had never been grease-banded. There is no doubt that frost was the cause. Nailing down the lifted bark caused neater healing. Reputable makes of greasebanding material may be applied direct to the bark, with a saving of paper, and with no risk of damage.

In Relation to Small Fruits.

Strawberries, Straw and Frost. W. S. ROGERS. Fruit-Grower, 1943, **95**, 393-4. (Esf48.)

Records of temperatures 1 inch above bare ground and above a layer of straw on frosty nights showed minima averaging 4·4° lower over straw than over bare earth. Thus the straw acts as a blanket preventing radiation of the earth's heat at night to objects above it. Strawberry blossoms with straw below them are thus exposed to greater cooling and greater risk of frost damage than unstrawed plants. Conversely, placing straw above the blossom on frosty nights would have a protecting effect. Practical recommendations are to avoid insulating layers, such as weeds, and to delay applying straw until as late as possible. These treatments directly affect radiation, and the effects upon and from convection currents are additional.

Five New Raspberry Seedlings. N. H. GRUBB. Rep. E. Malling Res. Sta. for 1942 (1943), 31-3. (Esf49.)

Reliable Strawberry Runners. W. S. ROGERS. Fruit-Grower, 1943, **96**, 203. (Esf50.)

The Strawberry nuclear stocks scheme of the Ministry of Agriculture, in which selected stocks are being raised in isolated nurseries under the most stringent conditions of disease and pest control, is described. In the first year, over 900,000 runners of Royal Sovereign were produced. In the second year, the variety Huxley was also included, but of course in entirely separate nurseries. A note is given on the difference between the Sovereign clones M35 and M40.

Horticultural Meteorology.

Weather Conditions during 1942. H. C. CHAPELOW and H. M. TYDEMAN. Rep. E. Malling Res. Sta. for 1942 (1943), 33-6. (H44.)

Miscellaneous.

The Experimental Farm. Section I. J. AMOS, F. H. BEARD, R. J. GARNER, D. H. HAMMOND, R. G. HATTON, T. N. HOBLYN, H. B. S. MONTGOMERY. Rep. E. Malling Res. Sta. for 1942 (1943), 11-13. (E198.)

General Review of Research Work, with Lists of Papers published during the year. Section II. Rep. E. Malling Res. Sta. for 1942 (1943), 14-30. (E199.)

Plants and Their Water Supply. W. S. ROGERS. Rep. E. Malling Res. Sta. for 1942 (1943), 103-4. (P7.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN

The decision of the Ministry of Agriculture to carry out a National Fruit Census in January, 1944, has occasioned new interest in the productive capacity of English orchards. One of the objects of the Census is the forecasting of yields, but to achieve this end it is necessary to find out what constitutes a heavy, average, or poor crop, of different kinds and varieties of fruit. As a contribution to this knowledge the recorded yields of a considerable number of trees at the Station have been resummarized to give a picture, not of the comparative effects of different treatments, but of the performance of certain plantations as a whole, usually over a period of some twenty years. While there are obvious difficulties in relating the yields of experimental plantations to those of commerce, it is thought this picture is not entirely without value, especially in view of the paucity of other accurate information. The history of certain apple plantations has been published (E192), and a similar account for pears is included in this Report (see p. 71). (See also I. A.)

The problem of comparing the growth of variously treated trees by means of different measurements of vigour, such as shoot growth and cross section of stem, has been discussed in a recent report (E197). (See Summary below.)

The monthly averages for the principal weather records, since they were begun at the Station, have been summarized in a readily available form.

Sampling.—An account has been published of the search for sampling methods to lighten the work of recording the total weight of an apple crop and the size of the fruit, as shown by the mean weight of an apple (E195). For crop weight, it is sufficient to weigh one box from each tree and to count the remaining boxes. Even this may be reduced if the number of trees is large. Methods of calculating the total weight from such records were discussed. Sampling for size from the top boxes of stacks of three by means of a section through the crop were described. These methods have been tried further in 1943 and extended to pears and plums. This work has now been virtually completed and the results are ready for publication.

The investigations of the variability in amount and intensity of apple scab, both on the fruits and leaves, have suggested sampling techniques which are now being tried. (See also V. A.)

Variation Studies.—Plans have been drawn up for an intensive study of hill to hill variation in the P.V. of hops of a single clonal variety. (See VIII. A.)

A trial has been initiated to find out how far hasty spraying may influence the variability of the results of spraying trials.

Two outdoor tomato variety trials, duplicated in the walled garden at Bradbourne and at Wilmington, afforded an opportunity for obtaining some information about the variation to be expected in trials of this crop. Like earlier trials on strawberries, raspberries and currants at the Station, these experiments emphasized the effect of disease on variability. In the Wilmington trial, wherein a large proportion of the plants were affected with virus disease, the variation was much higher than in the Bradbourne trial, in which the number of plants affected was comparatively small.

Experimental Design. -In recent years restrictions on fruit planting have largely prevented the establishment of new experimental orchards. In designing new trials it has generally been necessary to " make do " with established trees, some of which have been in more than one previous trial. A considerable planting programme is therefore inevitable as soon as conditions permit. Some of the orchards will be devoted to specific trials, say of new rootstock selections. Apart from these, however, there is always a need for established trees of known history, which may be used for various kinds of experiment as occasion arises. For this purpose it is proposed to plant orchards which are uniformly treated at the start, but which are capable of sub-division into plots at some future unspecified date. The design must be elastic, so that the number, size and shape of the plots can be adjusted to the needs of the experiment and guard plants allowed for if needed. One such plantation of black currants, has already been planned containing four varieties in large plots, designed so that they can be subdivided in several different ways.

Plantations of top fruits are more difficult to plan. It is probable that in some of them different methods of cultivation will have to be compared. The problem is to design a " plot " of such a size and shape that the cultivations within it can be normally and adequately carried out, and yet small enough to allow of sufficient replication. At the same time essential guard trees must be reduced to a minimum.

A complex exploratory trial designed to test measures of controlling Bacterial Canker in plum trees, by the use of resistant stem-builders, by time of pruning and by spraying has been described. (C190. See V. A.)

In the field trials carried out on derelict land by the mineral deficiencies team, soil heterogeneity of an extremely patchy nature has been encountered. The use of systematic controls adjacent to each differently treated plot seems a possible means of overcoming the high variability in the yields which results. (See IV.)

PUBLICATIONS DURING THE YEAR

The Production of the Fruit from Four Experimental Plantations at East Malling, 1920-1942. T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1942 (1943), 96-102. (E192.)

The Value of a Fruit Farm Census. T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1942 (1943), 93-6. (E193.)

An investigation into means of Reducing the Labour needed for Recording Crops. S. C. PEARSE. Rep. E. Malling Res. Sta. for 1942 (1943), 36-40. (E195.)

The Statistical Interpretation of Vigour Measurements of Fruit Trees. S. C. PEARCE. J. Pomol., 1943, **20**, 111-15. (E197.)

Evidence is given to show that in applying the analysis of variance to measurements of tree weight, extension growth, and either girth or area of cross-section of stem of fruit trees, it is better to use the logarithms of the data. This result was arrived at by consideration of the stability of the variances with different means, and the normality of the distribution of these measurements.

III. PLANT PHYSIOLOGY

By M. C. VYVYAN

Vegetative Propagation (See also I. A.)—A report on several years' work on the propagation of fruit tree rootstocks by hardwood cuttings has been published (F38). Rooting performance was found to vary greatly with the variety and considerably with the season. Source of material proved important, Myrobolan B cuttings rooted best when taken from a hedge. Etiolation was tried with one variety—Common Mussel—and found to improve the rooting of a basal cutting, which included the etiolated portion, but depressed rooting in a cutting taken high up in the same shoot. Ringing, notching or slitting the bark of the shoots, either some time before the cuttings were made, or at the time they were taken, gave no conclusive results. Some evidence was found that cuttings root better when their upper leaves are not removed. Shelter of the cutting bed by windbreaks of hop lewing and shading with muslin were usually harmful. The greatest improvement in rooting and in size was obtained by a layer of " humus " (sphagnum moss or spent hops) under the sand of the cutting bed.

In a further report on hardwood cuttings, summarized below (F37), Myrobolan B cuttings, taken from four sources were shown to differ widely in rooting performance.

Spraying to reduce pre-harvest drop of fruit.—A progress report (F39) has been published on the results obtained in 1942. Trees of Conference pear, sprayed with four parts per million alpha-naphthalene acetic acid, lost only 2 per cent. of their good fruit, whilst unsprayed controls lost more than 18 per cent. Bad fruit dropped as freely from the sprayed as from the controls. There were indications that sprays of the same substance and of alpha-naphthalene acetamide, at a concentration of six parts per million, considerably reduced drop in Bramley's Seedling apples. In 1943, with the apple Worcester Pearmain, a spray of ten parts per million alpha-naphthalene acetic acid, put on about three weeks before the apples were picked, resulted in an average gain of about $1\frac{3}{4}$ bushels of marketable fruit per tree. Other experiments were carried out on Conference pear, Bramley's Seedling apple and Cox's Orange Pippin, and the results are being examined statistically. A full report of all the work up to date is being prepared for publication.

PUBLICATIONS DURING THE YEAR

Studies on the Vegetative Propagation of Fruit Tree Rootstocks II. By Hardwood Cuttings. M. C. VYVYAN and A. C. SINHA. J. Pomol., 1943, **20**, 127-35. (F37.)

Three experiments on the rooting of hardwood cuttings of fruit-tree rootstocks were carried out and the results analysed statistically.

1. Cuttings of the plum rootstock Myrobolan B were taken from four sources, with the top cut either just above or just below a bud, and planted in soil, either with or without irrigation. (*a*) Source of material proved very important ; cuttings from a mature hedge rooted 80%, from a layer bed 69%, from budded layers 47%, and from one-year-old rooted cuttings only 28%. (*b*) Neither position of top cut nor irrigation had a significant effect.

2. Cuttings of two plum rootstocks, Common Mussel and Pershore, were taken from the tips, middles and bases of shoots, whose bases either had, or had not, been etiolated. Some of each kind were treated with 20 p.p. million indolebutyric acid before planting, the remainder with distilled water. (*a*) Common Mussel rooted much better than Pershore. (*b*) Relative rooting of tips, middles

and bases depended on variety and etiolation treatment. (*c*) Previous etiolation of the base of the shoot improved rooting in basal cuttings of both varieties and in tip cuttings of Pershore, but reduced rooting in middle cuttings of Common Mussel. (*d*) Treatment with the growth substance greatly increased rooting in basal and middle cuttings of both varieties.

3. Cuttings of two plum rootstocks, Myrobolan B and Pershore and two apple rootstocks, M. II and IX, were treated before planting, with either indolebutyric acid or its potassium salt, at three different concentrations, or with distilled water, either in continuous light or darkness. (*a*) Rooting in Myrobolan B was good, in Pershore and M. II, moderate, and in M. IX too poor to be worth recording. (*b*) Treatment had no significant effect, at any concentration, whether the acid or the salt was used, or whether carried out in the light or in darkness.

The Propagation of Fruit Trees by Stem Cuttings. III. Further Observations on Hardwood Cuttings. M. C. VYVYAN. Rep. E. Malling Res. Sta. for 1942 (1943), 40-7. (F38.)

Sprays to Control Pre-Harvest Drop of Fruit. M. C. VYVYAN. Rep. E. Malling Res. Sta. for 1942 (1943), 47-8. (F39.)

IV. BIOCHEMISTRY

By W. A. ROACH and B. D. BOLAS

As already reported, the Agricultural Research Council has augmented the team formed by the association of Dr. B. D. Bolas and Dr. D. W. Goodall, of the Research Institute of Plant Physiology, with the Biochemistry Section to enable it to extend work to potatoes, cereals and other crops of particular importance to the country during the war. A report on this work has been made to the Agricultural Research Council. Field trials were carried out on making good the deficiencies detected in 1942, e.g. manganese in the marshlands of Kent, and calcium, phosphorus and magnesium in the marginal lands of Devon. (See also II.) Calcareous applications on the latter areas made in 1943, as a result of recommendations made in 1942, led to an increase of 3,000 tons of potatoes.

Although the energies of this team have been directed mainly towards agricultural crops, work has continued on fruit.

Plant Analysis Methods.—A number of sources of error in the flame method of spectrography developed here have been eliminated and its accuracy has been increased considerably. Speed of operation has also been improved. A description of the method will be published shortly. Cleaning, drying and grinding the samples takes two or three days. After this has been done the labour involved in preparing spectrograms of a batch of samples for diagnosis by inspection is at the rate of about 15 minutes per spectrogram. When quantitative analyses are made the time taken is about 20 minutes per spectrogram for the preparation of the spectrograms, and the time for photometry and computation for each line is about 2 minutes. The method requires only 1/50 the amount of material needed by the Lundegårdh, but is less accurate. Dr. Goodall's latest figures suggest that it has an error figure about 50 per cent. greater than the Lundegårdh ; it is almost twice as rapid as the usual Lundegårdh method, though less rapid than that method when a step sector is used with it.

A Hilger large quartz spectrograph, provided by the Agricultural Research Council, has been installed and on it has been done routine work using the A.C. arc. The non-delivery of apparatus on order has held up work on the D.C. arc, on the spark method devised by Roach and on the, Lundegårdh method.

A polarographic method has been evolved for the estimation of zinc in plant material and is now in routine use. Work has also been done on other elements. The volatility of zinc, copper and other elements has necessitated the working out of special methods of ashing the plant material.

The provision by the Agricultural Research Council of a Spekker absorptiometer has increased the efficiency of the colorimetric methods used.

Phosphorus is determined by a molybdenum blue method, reduction being brought about by quinhydrone and sodium sulphite. The time taken has been about 30 minutes per sample, with a standard deviation of about 10 per cent. between replicates.

The quinalizarin method for the colorimetric estimation of boron has been brought into routine use. It is rapid (say 25 minutes per sample) with a standard deviation of about 10 per cent.

Work has also been done on the d-d'-dipyridyl method as a means of estimating iron in the ferrous state. The time required would be about 30 minutes per sample.

If, as results so far obtained suggest, phosphorus, boron, zinc and iron can be determined on aliquots derived from the products of one ashing the time per analysis for each element will be reduced to 10 minutes.

Results of Analysis.—Quantitative analyses have been made by the above methods of leaves from apple trees growing over various cover crops in experiments carried out at the Research Station.

(See I. A.) The leaves of trees growing over grass contained more phosphorus than those over clean cultivated ground and the results suggested an association between interveinal leaf scorch and basal defoliation with low phosphorus content. No conclusion can be drawn in respect to potassium, magnesium and boron until analyses now in hand are completed. In addition routine diagnoses have been made for advisory purposes on 127 leaf samples of various kinds of fruit-producing plants sent by growers from many parts of the country.

Dr. D. W. Goodall has published some results of his analytical work on the leaves of Cox's Orange Pippin apples on the manurial plots at East Malling (K39). (See Summary below.)

Results which have not yet been analysed completely show substantial effects of rootstock in regard to magnesium and potassium. The distribution of potassium between different types of leaves was affected but there was no such difference in respect of magnesium.

In samples collected from 25 trees from various parts of the Research Station showing differing degrees of leaf scorch there were no consistent differences between the mineral contents of scorched and healthy leaves from the same tree, except for the magnesium content which was often lower in scorched leaves of magnesium-deficient plants and sometimes higher in scorched leaves of potassium-deficient plants.

An interesting effect of " intermediate " graft was shown by leaves of Egremont Russet topworked on Bascombe's Mystery on rootstock M. V ; they contained very much more potassium than immediately adjacent trees of Egremont Russet worked directly on to rootstock M. V.

Publications during the Year

Studies in the Diagnosis of Mineral Deficiency. I. The Distribution of Certain Cations in Apple Foliage in Early Autumn. D. W. Goodall. J. Pomol., 1943, **20**, 136-43. (K39.)

Samples were taken of apical, middle and basal leaves from primary long shoots, from primary non-bearing spurs, and from secondary spurs on bearing spurs of trees of Cox's Orange Pippin apple on Malling rootstock XII. The trees were receiving eight different manurial treatments. The samples were analysed for calcium, iron, magnesium, manganese and potassium.

Samples from plots receiving double potash applications contained 58 per cent. more potassium than those from plots receiving a single application ; samples from plots receiving sulphate of ammonia contained 42 per cent. more manganese than those from the no-nitrogen plots.

The potassium content was highest in leaves from the middle and apex of the long shoots ; the content of the other elements was highest in the basal leaves of the non-bearing spurs. In general, for all elements except potassium, the content declined as the date of leaf formation became later in the season, but rose slightly again at the end of the season.

Differences in manganese and potassium status of different trees are reflected more clearly in the composition of the basal leaves of the non-fruiting spur than in that of other leaf types investigated.

V. PLANT PATHOLOGY

By R. V. HARRIS

A.—Diseases of Tree Fruits.—*Bacteriosis of Plum and Cherry Trees.*—The results of two trials on the prevention and control of Bacterial Canker of plum trees, published during 1943 (C190), showed that the working of stems and crotches of certain plum varieties resistant to this disease with the susceptible Victoria (" stem-building ") was highly successful in avoiding stem cankers. Spraying the foliage with Bordeaux mixture, particularly three weeks after petal-fall and later, controlled the leaf " shot hole " stage of the disease and reduced the number of branch (but not stem) cankers. One of these trials was continued with certain pruning modifications and the omission of all differential spraying issues, and the resistance of certain stem pieces was maintained during 1943. (See also I. A and II.) A trial was started on a series of young Victoria trees on their own stems to find the best time for autumn spraying.

The collaborative study of the physiology of resistance of certain plum varieties to this disease was terminated in September, 1943, with Mrs. D. Oxford's transfer to other work. The results are being summarized for publication.

Bacterial Diseases of Morello Cherry.—A preliminary account of bacterial diseases of Morello cherry trees was published (C198). Two organisms, which can be distinguished by their cultural characters, have been isolated from leaf spots, wilted blossoms, fruit, and fruit stalks ; one of these organisms has also been isolated from stem and branch lesions.

Silver Leaf.—(*a*) *In relation to Papery Bark Cankers of Apple.*—A paper has been published (C189) describing the association of the Silver Leaf fungus, *Stereum purpureum*, with papery bark cankers on

grafted apple trees. (See Summary below.) Experiments to obtain further information on the relation between Silver Leaf and papery bark have been made during 1943.

(*b*) *Injection of Plum Trees with Fungicide.*—Isolations from plum trees infected with Silver Leaf and injected with Chinosol showed that *Stereum purpureum* was still alive in infected tissues. Tests with dye solutions proved that the diseased wood was not penetrated, and the use of an injection pump failed adequately to improve penetration. Liquid injections of this type are therefore unlikely to bring about a permanent cure of Silver Leaf disease.

Wilting of Plum Shoots in Layer Rows.—An account of field observations on this disease, with a preliminary description of the fungus causing it, was published (C188). As many as 50 per cent. of the layer shoots have been killed in some instances. Control measures suggested are (i) raising layer rows from cuttings when this is practicable, (ii) avoiding propagation from plots with infected shoots, or disinfecting the stocks before transplanting them. (See also I. A.)

Apple Scab.—(*a*) Methods of measuring the intensity of the disease on apple foliage were further studied, and a promising one received extensive field test on a statistical basis. (See also II.) (*b*) The experiment to test the effect of spraying in bloom again gave positive results, increased Scab-control being safely obtained. (*c*) The field trial of new fungicides was continued with the Plant Protective Chemistry Section. (See VII.)

Apple Canker.—The field spraying trial yielded no results because of a general absence of infection. A study of methods for inducing infection in the field was therefore started, together with a further spraying trial on a grower's plantation in a highly infected area of Kent.

B.—Diseases of Soft Fruits.—*Virus Diseases of Raspberry.*—*Varietal and seedling tests.*—A sample of one of the most promising East Malling seedlings tested in 1942 proved to be wholly "virus-free" (i.e. no canes induced symptoms on the indicators in 1943). The remaining three seedlings were found to be highly infected with, and tolerant of, Mosaic 2. Tests to determine the mosaic virus status of six other seedling varieties were started.

An experiment was started with selected stocks of the Lloyd George variety to find the relation between its present-day deteriorated condition and masked infection with Mosaic 2 virus.

Virus Analysis.—Experiments with three species of aphides as possible vectors of raspberry virus was started in 1943. The experiment set up in 1942 to investigate a suspected virus in apparently normal canes of the indicator variety, Baumforth's Seedling B, provided conclusive evidence of a negative character. (For serological tests see under *Strawberry* below.)

A Leaf-curl Disease in Scotland.—The investigation of a serious outbreak of this disease in plantations of the Norfolk Giant variety in the intensive raspberry growing area of Angus and Perthshire started in 1942 was considerably developed in 1943, when a preliminary account of symptoms together with suggested precautionary measures against its spread was published (C191). During 1943, the disease was shown to be a graft-transmissible virus disease, and further grafting experiments were started to test observations suggesting that local stocks of the widely planted Lloyd George variety may provide a major source of infection of Norfolk Giant. The disease as so far studied closely resembles the leaf curl diseases of raspberry in North America, in particular the Yellow Blotch Curl disease recently described by Chamberlain.* Outside this Scottish area no outbreaks were found excepting the occurrence of the leaf-blotch symptoms on a wilding in the London district and on a seedling variety at East Malling.

Virus Disease of Strawberry. Varietal tests.—Further samples of commercial varieties (including seven new varieties and ten selections of Huxley's Giant) were tested by inarching to *Fragaria vesca*.

Nuclear stocks of selected clones were maintained in the glasshouse under aphid-free conditions.

The investigation of the causes of deterioration of vigorous stocks of Huxley's Giant was continued, but no further important developments were forthcoming during 1943.

Virus Analysis.—The analysis of the virus content of infected plants by means of the vector *Capitophorus fragariae* was further developed and yielded positive results. Evidence that Yellow-edge and Crinkle are caused by virus complexes is thus accumulating and it is believed that four distinct viruses have now been isolated.

Efforts to identify strawberry and raspberry viruses by serological means, undertaken by the Rothamsted Experimental Station, were continued during the year, but have now been terminated owing to the difficulties encountered and negative results obtained.

Loganberry Cane Spot.—The results of this the sixth year of the spraying trial confirmed that an effective basic control schedule has been achieved. (See also I. B.)

C.—Diseases of Hops.—(See VIII B.)

D.—Miscellaneous Investigations.—*Verticillium Wilt.* (See also VIII.)—The results of cultural and pathogenicity studies of various strains of Verticillium failed to indicate any differences between solates from "progressive" and "fluctuating" outbreaks on hop respectively. They further

* 1938. *Canad. Journ. Res.*, C16, 118-24.

supported the accordance of distinct specific rank to isolates provisionally referred, on morphological and physiological grounds, to *V. Dahliae* Kleb., *V. albo atrum* R. and B., and *V. nigrescens* Peth. respectively.

Verticillium Wilt of strawberries caused serious losses to growers in Cambridgeshire (Histon and Wisbech) and Kent, and the disease was investigated. Arrangements were made to develop the study of this disease and also of the analogous disease on potato, severe attacks of which were also observed in Kent.

Verticillium spp. were also isolated from peppermint, sage, black raspberry and red raspberry, and tomato for comparative studies.

Nut Drop.—A disease of cobnuts causing premature dropping of the fruit was observed in the summer of 1943. Several fungi were found on or in affected nuts ; the one obtained most frequently was *Monilia fructigena*, the common Brown Rot fungus of apples and pears. See also page 56.

PUBLICATIONS DURING THE YEAR

Sun-Scald of Fruits. M. H. MOORE and W. S. ROGERS. Rep. E. Malling Res. Sta. for 1942 (1943), 50-3. Reprinted from Gdnrs Chron., 1942, **112**, 166-7, with an addendum. (C186.)

Field Observations on the Cylindrocladium Shoot Wilt Disease of Plum and Cherry Layers. H. WORMALD. J. Pomol., 1943, **20**, 80-3. (C188.)

A wilting of shoots in layer rows of plum and cherry varieties raised for rootstocks has been found to be caused by a fungus, which at present is considered to be a cultural variety of *Cylindrocladium scoparium* Morgan. The fungus fructifications are rarely found on the wilted shoots although microsclerotia usually occur on them. The fungus has been isolated directly from lesions on the wilted shoots and from conidia and proved to be parasitic, but details of the experiments are reserved for a future paper. Certain control measures are tentatively suggested.

Papery Bark Canker of Fruit Trees in Relation to Silver Leaf Disease. H. WORMALD. J. Pomol., 1943, **20**, 144-6. (C189.)

Topgrafting, involving cutting back large limbs of fruit trees, is often soon followed by the appearance of papery bark cankers on branches and stems ; this is frequently accompanied by Silver Leaf. The conditions favouring the formation of papery bark—cutting back the main branches when the tissues contain an abundance of sap—also favour infection by *Stereum purpureum*. Isolations from the discoloured wood of a number of grafted trees showing papery bark all yielded *Stereum purpureum*, except one from which *Polystictus versicolor* was isolated. The advantages of frameworking over topworking for apple trees are emphasized.

A Field Trial of Measures designed for the Control of Bacterial Canker of Victoria Plum Trees. H. B. S. MONTGOMERY, M. H. MOORE, and T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1942 (1943), 53-61. (C190.)

A Leaf Curl Disease of Raspberry in Scotland. R. V. HARRIS, A. D. BRYCE, and C. E. FOISTER. Rep. E. Malling Res. Sta. for 1942 (1943), 48-50. (C191.)

Bacterial Diseases of Acid Cherry Trees. H. WORMALD. Rep. E. Malling Res. Sta. for 1942 (1943), 61-2. (C198.)

Some Fruit Diseases Seen on Survey in Kent. H. B. S. MONTGOMERY and M. H. MOORE. Rep. E. Malling Res. Sta. for 1942 (1943), 104-7. (C199.)

VI. ENTOMOLOGY

By A. M. MASSEE

A.—Tree Fruits.—*Apple Blossom Weevil.*—New details have been added to our knowledge of its life history. The egg laying period is now better defined and the number of eggs laid by individuals known. An estimate of the numbers of adults hibernating on the tree and elsewhere has been made. Control measures have consisted of :

(*a*) Repellants. None of these proved satisfactory.

(*b*) Dusts. Several gave promising results under controlled conditions. (See also VII. A.) The only one used on a field scale failed to give a control.

Woolly Aphis.—Vaporized nicotine is being tried as a means of control of Woolly Aphis in the stool-beds.

Woolly Aphis Parasite.—The life-cycle of this insect, which is now established in several orchards in Kent, is being studied. Experiments to overwinter the parasites in dry and in cold storage are in progress.

B.—Small Fruits.—*Strawberry Aphides.*—At least seven species have been found breeding on cultivated strawberries, one of them not previously recorded for the British Isles.

Three distinct sexual forms of *Capitophorus fragariae* have been bred in the laboratory. One, the alate male, previously known only from America, may help to clear up the synonymy of this species.

Strawberry Aphis Survey.—Population counts made on selected farms in Hampshire, Worcestershire, Isle of Ely and Kent gave information on the duration and intensity of the migrant phase, also the rate at which clean beds become infested.

Regular samplings have continued on all the Research Station plots and the Nuclear Stocks situated in Kent.

Vaporized Nicotine Treatment for Strawberry Aphis.—All strawberry plots on the Research Station have again been fumigated. The subsequent build-up of populations was recorded by sampling. As an alternative to treatment of runners after lifting it was found that a late application of nicotine vapour gave a commercially useful control of aphis.

Gooseberry and Currant Aphides.—A start has been made on the biology of species living on these plants.

Rubus Insects.—A weekly survey is being made on two plots of raspberry, of which one is sprayed at regular intervals. The difference in growth of the two plots is outstanding.

Reversion of Black Currant.—The Black Currant Gall Mite associated with " big bud " has been tested again as a possible vector of reversion. A new technique for making the inoculations has been devised. Negative results have resulted from the tests made with *Lygus pabulinus* L. in 1943.

Control of Tarsonemid Mite.—Observations on strawberry runners fumigated with methyl bromide show that the dose required to kill the mites and their eggs is injurious to the plant. Further tests are in progress.

Black Currant Leaf-curling Midge.—A further study of the life-cycle of this obscure pest has been made in the field, including a search for the overwintering cocoons of the midge.

Systematic Study of the Phytoptidae.—Specimens sent in by economic entomologists have been investigated and determined.

The British Tetranychidae or Red Spiders.—A number of species received from various sources have been examined in detail, and at least two of them prove to be new to the British list. One of them is a species of economic importance on the Continent of Europe.

Publications during the Year

Notes on Some Interesting Insects Observed in 1942. A. M. Massee. Rep. E. Malling Res. Sta. for 1942 (1943), 64-8. (D173.)

A Note on Apple Sucker. A. M. Massee. Rep. E. Malling Res. Sta. for 1942 (1943), 107. (D174.)

The Egg of *Eurydema dominulus* Scop. (*Hem., Pentatomidae*). A. M. Massee. Ent. Mon. Mag., 1943, 79, 125. (D175.)

A description is given of the egg of this red and black shield bug, which occurs locally in the woods in the Maidstone district where *Cardamine pratensis* L. grows.

The Egg of *Euacanthus interruptus* L. (*hem., Jassidae*). A. M. Massee. Ent. Mon. Mag., 1943, **79**, 270. (D176.)

A description of the egg is given from a number of ova extracted from chestnut poles. The eggs are laid in the chestnut poles of the hop garden in August. The winter is spent in this stage. The insect does not overwinter in the adult state as suggested by former workers.

VII. PLANT PROTECTIVE CHEMISTRY

By H. SHAW

Late in 1942 the Insecticides and Fungicides Section of the Research Station was extensively reorganized and gave place to the Plant Protective Chemistry Section. Most of the main lines of work have been continued unchanged in the new Section, but work of a more purely biological nature has been absorbed in either the Plant Pathology Section or the Entomology Section, and is reported under the appropriate Section headings.

A.—Laboratory Investigations.—**Ovicides.**—A series of mono-, di-, and trinitroxylenols, prepared by the Chemical Research Laboratory of the D.S.I.R., was tested against eggs of *Aphis pomi*. Of the eleven substances none gave an appreciable kill of the eggs when applied at 0·08 per cent., whereas neither 3 : 5-dinitro-*o*-cresol nor 2 : 4-dinitro-*o*-cyclohexylphenol at 0·04 per cent. under exactly comparable conditions allowed a single egg to survive. Three chlorinated phenols and two dipiperidyls were ineffective at 0·04 per cent. Nicotine was about five times as toxic as a preparation of the mixed alkaloids of *Anabasis aphylla*.

Further evidence was obtained on the relative toxicities of distillates from horizontal retort or

coke-oven tar, vertical retort tar, and low temperature tar. Fractions of these distillates cut between 320° and 380° C. showed similar toxicities for ranges of concentrations in the ratio 1 : 2 : 4.

In association with the Insect Physiology Unit of the Agricultural Research Council and with the Zoology Department of Cambridge University, work has been resumed on the physiology of ovicidal action. Attempts are being made to measure the respiration of treated and untreated eggs by a manometric method.

Contact Insecticides.—4 : 4′-Dichlorodiphenyltrichloroethane was found to be about as toxic as nicotine to adults of *Aphis rumicis*. A proprietary dust containing 5 per cent. of this same material was the most effective of several substances, including derris and dinitrocresol dusts, tested against Apple Blossom Weevil. (See VI A.)

Fungicides.—As a result of changes of staff only a few tests were carried out during the year. In a series of alkyl mercury chlorides, toxicity to spores of *Venturia inaequalis* increased progressively from methyl to *n*-amyl, though none of the five was as toxic as phenyl mercury chloride.

Spray Damage Investigations.—Chemical analyses showed that while lead arsenate is substantially unaffected by carbon dioxide, calcium arsenate reacts slowly and much of the arsenic passes into solution. This fact affords an explanation of the behaviour of calcium arsenate in the field, where serious damage has often been noted several weeks after spraying.

B.—Field Investigations.—Insecticide Trials.—Several trials were carried out with "Guesarol" preparations containing as toxic ingredient 4 : 4′-dichlorodiphenyltrichloroethane. Against Raspberry Beetle on loganberries results were obtained that compared very favourably with those following spraying with lonchocarpus. Against Apple Sawfly "Guesarol" was inferior to nicotine when applied at about the optimum time for control, but there was little difference between the two when they were applied about a week later. There appeared to be a residual effect of the "Guesarol" similar to that shown by derris. "Guesarol" failed to control Bean Aphis (*A. rumicis*) whereas nicotine was completely effective. This failure appeared to be due to the unsatisfactory wetting properties of the preparation.

Fungicide Trials.— *Apple Scab.*—The trial begun in 1941 was continued for a third year. Adverse weather conditions interfered with spraying and allowed Scab to develop early. The sprays were less effective than in previous years, but lime-sulphur was again the best of the sulphur group. Phenyl mercury chloride maintained its high promise and was outstanding. Further work is necessary on the phytocidal properties of this material, for in 1943 it was again of doubtful safety.

Publications during the Year

Behaviour of Thiuram Sulphides, etc., in Spore Germination Tests. H. Shaw and H. B. S. Montgomery. Nature, 1943, **151**, 333. (Q31.)

In an examination of the effect of some dithiocarbamates and thiuram sulphides on germinating spores of *Venturia inaequalis*, it has been observed that in many cases an inversion of toxicity occurs. Since this inversion may appear only within a very short range of concentration, it is often difficult to detect, but it seems to be a general property of this group of compounds. It is suggested that an explanation is probably to be found in the chemical lability of these substances.

Field Trials of Phenyl Mercury Chloride for the Control of Potato Blight. H. B. S. Montgomery and H. Shaw. Rep. E. Malling Res. Sta. for 1942 (1943), 68-70. (Q33.)

Wartime Spray Programmes for Fruit in the South-Eastern Counties. W. Steer and M. H. Moore. Occ. Pub. Sci. Hort. **4**, 1943, 71-6. (Q34.)

The need for maintaining pest and disease control in wartime is emphasized. The Schedule proposed covers essential winter, spring, and summer washes for top fruit and soft fruit, and includes recommendations for specific pests and diseases, with notes on spray damage, varietal susceptibility, and a spray programme for gardens.

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial Varieties. The proposed cropping trial of Goldings has been planted in isolation at Bradbourne. A propagation plot has been laid down of the best of the three Fuggle strains so far tested. Material is being collected for a trial of other strains, including some that are earlier in season than normal. The original Fuggle strain trial is being retained for use in an experiment designed to measure what variation in P.V. occurs from hill to hill in clonal material. (See also II.)

The chief characteristics of commercial varieties of hops at the Station have also been compared (B41).

New Varieties. –The merits of the outstanding new varieties of hop raised by Professor Salmon and tested at East Malling have been summarized and a report published (B39). In 1943 the crops from some 115 varieties were dried separately in order that the yield per acre could be estimated and samples taken for analysis if required. Samples of 42 varieties, many not previously analysed, were saved for P.V. determination. The crop from 37 varieties was pressed in part pockets for use in brewing tests. Analyses of the 1942 crop showed that five varieties, OT91, V32, R4/40a, AII16, and R3/97a, were of sufficient merit to deserve brewing tests. The systematic testing of the new varieties for resistance to Verticillium Wilt was continued (see B below). The above work has been carried out in collaboration with Professor E. S. Salmon of the S.E. Agricultural College, who has published a report (B46).

Cultural Trials. –The effects of stopping and of number of bines to a string on a vigorous late variety (OV7) have been described (B44). The recent large scale plantings are not yet sufficiently mature to allow of new trials being initiated.

For the first time in the history of the trial with Brewer's Favourite, severe pulling significantly reduced cropping, whilst the distance of planting had no effect. Usually the effect of distance of planting is more marked than that of severity of pulling. The trial of different times of "dressing" combined with pulling treatments carried out on Quality Hop gave no significant differences in cropping though there were as usual big differences in the forwardness of the bine during the growing season. In the trial designed to test the effect of cutting the bines just below the breast wire (necessary if machine picking is employed) the plots having their bines cut again gave the lower yield, but this season it was not sufficiently lower than the normal plots to be significant.

Manurial Trial.—Owing to drought conditions the variety OI47 was a complete failure and no crop records were obtained. There was no indication that there was any differential effect due to the manurial treatments. Of recent years the New Mexican seedlings of which OI47 is a typical example have failed to give satisfactory crops at East Malling, though in earlier years they were amongst the heaviest croppers with yields of 30 cwt. and over per acre.

Propagation Trials.—Strap cuts of Brewer's Gold, Bullion Hop and Fuggle were again treated with a growth substance before planting. Varietal differences in response were again found, but on the whole the response was negative. An account of the experiment appears elsewhere in this Report (see p. 68.) A small trial to compare strap cuts with cuttings made from natural runners showed that the latter gave as good a "take", but that the resulting sets were considerably smaller, though quite satisfactory for planting out.

Root Studies.—The data obtained from the excavation of several hop hills on three soil types has been summarized and a report published (B40). See Summary.

B.—Diseases of Hops.

By W. G. KEYWORTH

Verticillium Wilt.—One hundred and fifty outbreaks have now been recorded since this disease was first discovered in 1924. Of these records, 67 were made in the 1943 season. This great number is due in part to the fact that many long-standing outbreaks of a mild type were reported during a Ministry of Agriculture inspection of hop gardens from which planting stock (cuttings) was to be taken. Further evidence was obtained, however, that the disease is continuing to spread from old established centres.

An experiment on soil disinfection as carried out in commercial practice showed this to be of doubtful value in large outbreaks, but more intensive measures appear more successful and are still advised for small outbreaks.

Two commercial experiments demonstrated that the application of large quantities of either dung or sulphate of ammonia had no effect on disease incidence in badly affected areas. In a preliminary experiment on artificial soil infection in two localities disease intensity (as measured by the number of wilted plants and the severity of symptoms) was much greater in one situation than in the other —a result apparently due to differences in soil conditions.

The resistance trials of the Wye seedling varieties were continued. Seven varieties were selected as showing a high degree of resistance in their first two years' tests. Brewing tests show at least three of these to be commercially acceptable.

Phytophthora Root Rot.—Further inoculation experiments demonstrated the pathogenicity of the *Phytophthora* sp. isolated from hops of the variety C9a showing root and stem rot symptoms, and a description (C192) of the first recorded outbreaks in Britain was published. Several more outbreaks

were seen in this variety both in Kent and the West Midlands, and the fungus was also obtained from Fuggle and Golding plants in widely separated localities.

C.—Insect Pests of Hops.

By A. M. MASSEE

Economic Vectors of Hop Virus Diseases.—A study was made of insect and allied fauna to find vectors of Mosaic and Nettlehead. Tests were made with immature forms of the Hop Shy Bug (*Calocoris fulvomaculatus* De Geer) collected from commercial hop gardens. Negative results have been obtained in tests made in 1942 with the hop thrips and the immature forms of the Hop-Damson Aphid.

A paper discussing the six most important pests of the hop, together with control measures has been published. (D172.)

Hop Strig Maggot.—The life-cycle and control measures in the field have been further studied.

Hop Frog Hopper.—New details have been obtained of the life cycle, including the discovery of habits of egg laying ; control measures in the field have been carried out.

Hop Eelworm.—A detailed study of the life-cycle of the Hop Eelworm (*Heterodera schachtii* Schmidt) and its association with the transmission of hop virus diseases has been started.

Publications during the Year

The Merits of the New Varieties of Hops. F. H. Beard, R. G. Hatton and E. S. Salmon. J. Inst. Brewing, 1943, **49**, 29-33, and Rep. E. Malling Res. Sta. for 1942 (1943), 108-11. (B39.)

Root Studies X. Root Systems of Hops on Different Soil Types. F. H. Beard. J. Pomol., 1943, **20**, 147-54. (B40.)

The results are given of excavations by the skeleton method of the root systems of a few mature Fuggle Hop plants on three types of soil, and those of single plants of Brewer's Favourite and Rodmersham Golding on two of these types. The soil profile and the root-system for each excavation is described. Each type of soil—well-drained loam overlying porous rock, brick-earth over a moist but well-drained loamy sand, and a poorly drained stiff loam with a high water table—is shown to induce the formation of a root-system characteristic for the type.

Comparison is made between the hop root-systems and modifications in the root-systems of apple trees, which have previously been recorded, due to soil conditions. Hop roots were found to be of two types : (1) Horizontal, tough and wiry, with considerable small root and fibre. (2) Vertical, fleshy and brittle, with little branching and no fibre. The proportion of each type of root was found to be governed by soil conditions.

Root plans and photographs of the reconstructed root-systems illustrate the text.

Commercial Varieties of Hops : A Preliminary Comparison of their Chief Characteristics at East Malling. F. H. Beard. Rep. E. Malling Res. Sta. for 1942 (1943), 77-83. (B41.)

The Problems and Practice of Hop Growing. The Culture, Drying, Diseases and Pests of the Hop. A. H. Burgess, F. H. Beard, W. G. Keyworth, A. M. Massee. Introduction by R. G. Hatton. J. Inst. Brewing, 1943, **49**, 118-38. (B43.)

A brief description is given of the principal varieties cultivated, together with the usual methods of cultivation. This is followed by a review of investigations both past and present, carried out at Wye and East Malling, on these aspects. The subject is dealt with under the headings, Soils, Varieties, Systems of Training, Distance of Planting, Dressing, Pulling, Training, Stripping, Cultivations and Manuring.

Signs of ripeness in hops are noted and reference is made to changes taking place in the cones during ripening. The process of Hop Drying is described ; results of experiments made at the Institute of Brewing Experimental Kilns, Beltring, Paddock Wood, are embodied in the account.

An account is given of the most important fungus and virus diseases of hops. These include Mould, Downy Mildew and Verticillium Wilt and the virus diseases Nettlehead and Mosaic. The control measures wherever established and the progress of recent research are considered. A number of diseases of more local importance, such as Canker, Armillaria Root Rot, Chlorotic Disease are also briefly mentioned.

An account is given of the habits and methods of control of the more important insects attacking the hop. They are the Hop Damson Aphis, Red Spider, Strig Maggot, Flea Beetle, Shy Bug, and the Common Earwig. Reference is also made to seven species of insects which have been tested as possible vectors of Mosaic and Nettlehead.

Cultural Trials with Hops. III. The Effect of " Stopping " and Number of Bines per String on a Vigorous late Variety (OV7). F. H. Beard. Rep. E. Malling Res. Sta. for 1942 (1943), 70-2. (B44.)

A Comparison of the Performance of Sets and Cuts of Hops when Planted in their Permanent Positions. F. H. BEARD. Rep. E. Malling Res. Sta. for 1942 (1943), 73-5. (B45.)

Twenty-Sixth Report on the Trial of New Varieties of Hops. E. S. SALMON. August, 1943.

1. Of the 118 varieties tested, one cropped at the rate of 30¼ cwt. to the acre, eleven at over 25 cwt. to the acre, and thirty-nine at 20 cwt. or over.

2. For the first time a number of the Anglo-American hybrid varieties were grown with only one bine to the string. "Brewer's Gold" and "Bullion Hop" yielded at the rate of 25½ cwt. and 29 cwt. to the acre, respectively. One variety yielded at the rate of 30¼ cwt. It is clear that many of these varieties (including "Brewer's Gold" and "Bullion Hop") are best grown commercially in this way and are to be regarded as belonging to the "One-bine Class".

3. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 76 to 150.

4. A Table (IV) is given of the preservative values of eight growths of "Brewer's Gold" and "Bullion Hop" produced commercially in Kent and Worcestershire. These values, with one exception, exceed those of the same varieties grown at East Malling Research Station and Wye College. The criticism raised in certain quarters that the New Varieties could be grown satisfactorily only under special conditions obtaining at Research Stations is thus shown to be without foundation.

5. Analyses by Mr. J. S. Ford, and also by Dr. T. K. Walker, showed that OM26, a clone plant and bud sport of the "Nonsuch Hop" (OB53) was richer than its parent by 1·10% α resin (2·29% of total soft resins) and 1·03% β resin (1·86% total soft resins). This superiority of a bud sport in the production of soft resins has now been shown for eight consecutive seasons; it is suggested that research should be directed to ascertain whether similar bud sports may exist in the Golding and Fuggle varieties.

6. A sample of "Brewer's Gold" from Agassiz, B.C., Canada, analysed on 25th January, 1943, gave the phenomenally high figures of 12·85% α resin and 11·75% β resins.

7. Information is given on the valuations accorded by the Hops Marketing Board to certain growths of the New Varieties. While it is satisfactory that some of the New Varieties, e.g. "Brewer's Gold" and "Bullion Hop", have been given top Golding prices, it is pointed out that, since there is more brewing value in them than any Golding, they should not be pegged down to prices fixed for Goldings. A fairer and more scientific method would be to establish a special class for the New Varieties (which might be called the Resin Class) and to base valuation on preservative value and the known performance in brewing trials. Such valuations have been made by Messrs. William Younger & Co. Ltd. on some of the New Varieties, the brewing value of which was assessed as follows, per cwt.: OM26, £30 16s.; "Nonsuch Hop", £27 16s.; "Brewer's Stand-by", £26 14s.; "Malling Midseason", £25 10s.; "Brewer's Favourite", £24 16s.; "Brewer's Gold", £24 6s.; "Bullion Hop", £23 18s.

8. Owing to the fact that in the last two years the Hops Marketing Board have fixed valuations equal to top Golding prices on some commercial growths of certain of the New Varieties (including "Brewer's Gold" and "Bullion Hop"), these varieties are now being planted up slowly in Kent and the West Midlands. The present demand by brewers for "Brewer's Gold" and "Bullion Hop", however, far exceeds the supply. It is suggested that if a quicker planting up is desired by brewers, they should induce the Hops Marketing Board to put a higher valuation on approved New Varieties, since there is more brewing value in them than in any Golding.

Insect Pests of the Hop. A. M. MASSEE. J. Inst. Brewing, 1943, **49**, 136-9. (D172, includedi n B43.)

A Phytophthora Disease of the Hop in Great Britain. W. G. KEYWORTH. Rep. E. Malling Res. Sta. for 1942 (1943), 62-3. Reprinted from Gdnrs Chron., 1943, **113**, 238. (C192.)

Diseases of the Hop. W. G. KEYWORTH. J. Inst. Brewing, 1943, **49**, 128-35. (C195, included in B43.)

IX. TECHNICAL SECTION

In acting as the link between the fruitgrower and the research worker, the Technical Section has dealt with an increasing number of advisory enquiries by letter, telephone and personal enquiry. It has organized the visits of parties of fruitgrowers, advisory officers and research workers to the Station and made known the findings of research through printed articles, films, photographs, and scripts for broadcasts in various parts of the world. Besides a regular contribution to the *Kent Farmers' Journal*, a total of twenty-six popular articles was published. It has also endeavoured to keep the fruitgrowers' point of view represented at all discussions of research work.

Section III

RESEARCH REPORTS

POMOLOGY

THE INFLUENCE OF DIFFERENT POLLENS ON THE GROWTH AND DEVELOPMENT OF THE FRUIT IN APPLES AND PEARS

II. FRUIT SIZE AND SEED CONTENT IN RELATION TO FRUIT DROP

By H. M. TYDEMAN

In the course of investigations into the effect of different pollens on the development of apple and pear fruits, opportunity was taken to examine the seed content of dropped apple fruits and of those remaining on the tree immediately following the " June drop " period, in order to see how far this drop could be attributed to defective fertilization.

In 1939, a season in which fruit drop in this locality was generally rather severe, fruits from trees of the three varieties, Cox's Orange Pippin, Worcester Pearmain and Bramley's Seedling were examined and their seed content compared with that of fruits which had fallen from the tree during the previous few weeks. The trees were of mature age, growing in plantations on various parts of the Research Station. The results are shown in Table I.

With both Cox's Orange and Worcester there was a very consistent relation between the size of the fruitlets and the number of seeds which they contained, in the fruits remaining on the tree and in those that dropped, the largest fruits containing the greatest number of seeds. In both the Worcester trees the dropped fruits contained only about half as many seeds on the average as the fruits left on the tree. The difference between the seed content of dropped fruits and of those on the tree was much less on the single tree of Cox's. The largest of the dropped fruits had almost as many seeds as the larger of the fruits which stayed on the tree. This suggested that a much larger proportion of all the fruits on the tree must have fallen in the case of Cox's than in that of Worcester, and this was certainly so since fruit drop on Cox's was particularly severe in 1939 while that on Worcesters was no more than normal.

Of the two trees of Bramley's Seedling on which observations were made, one (Tree A in Table I) showed little indication of any relation between fruit size and seed content in either dropped fruits or those remaining on the tree. Among the fruits from the other tree (B), and in the dropped fruits from a third tree (C), there was evidently a close connection. This difference between trees of the same variety is not very easy to explain, but it seems most probable that some external agency, such as insect or spray damage, may have caused a part of the drop in Tree A. The fruitlets of Tree A varied more in size than those of Tree B and were, on the average, somewhat larger at this stage, although they contained fewer seeds.

During the early summer of 1943, when fruit drop had again been severe, particularly in Cox's Orange Pippin, the seed content of fruitlets was recorded from four mature Cox's trees selected from widely different situations on the Research Station. The results of these seed counts are shown in Table II. Trees A and B were growing on the outside and towards the middle respectively of a plantation of bush trees in which the provision for cross pollination was not particularly good. Both had a fairly average " June drop ". On Tree C, widely separated from A and B, the June drop was notably severe, while on Tree D a fairly severe June drop was aggravated by the effects of spray damage.

Fruit size and seed content were again very closely related in both dropped fruits and those which remained on the tree in three out of the four cases. It is interesting to notice the difference in average seed content between fruits from Trees A and B, due to their different situations in the plantation. Although Tree A was on the outside of one plantation, it was within about 40 feet of another of a different variety, while Tree B must have been much more restricted for cross pollination. Since the seed content of the dropped fruits from the two trees was very similar, the drop from Tree B must have been more severe than that from Tree A, although this was not noticed at the time.

With Tree D, damaged by post-blossom lime sulphur spraying, there was no relation between fruit size and seed content, and the dropped fruits contained as many seeds as those which remained on the tree. However severe the fruit drop it could scarcely have affected the relation between fruit size and number of seeds, and it is probable that the spray injury affected the relative growth of the fruitlets.

Discussion.—Despite considerable research during recent times, many questions connected with the fertilization of the flowers of fruit trees remain unanswered. It is now known that incompatibility and sterility result from the interaction of definite genetic factors but the consequences of imperfect fertilization between compatible ovules and pollen and the causes underlying June drop or biennial bearing are not yet completely understood.

The gynaeceum of the apple shows a number of morphological differences some of which have been very clearly described by Bunyard (1912) and commented upon by Pearl (1932). The five stigmas in the apple flower may occupy three positions relative to the stamens, standing either well above them, level with them, or much below them. Again there may be a relatively long stylar column from the upper part of which the five stigmas branch out, or the five stigmas may be free almost to their base. While these distinctions were recorded previously for their diagnostic value, it is clear that they may affect the efficiency with which the flower can be pollinated by insects. In spite of the fact that they coalesce into a single column, either short or long according to the variety, each stigma appears to communicate with a single chamber of the ovary and the application of pollen to one stigma is capable of affecting development in one chamber only. The following data obtained by the writer with the pear variety Fertility illustrates the effect on seed production of fertilizing variable numbers of stigmas.

Number of stigmas pollinated.	Number of flowers.	Per cent. fruit set.	Average number of seeds.
One	25	16	0·7
Two	35	23	3·0
Three	31	32	4·1
Four	27	15	5·0
Five	14	28	5·2

While the number of stigmas pollinated evidently influenced the number of seeds contained in the fruit, it did not have any very marked effect on the proportion of flowers which set fruits, for the flowers with few stigmas pollinated produced almost as many fruits as the flowers apparently perfectly fertilized.

Apart from this effect of incomplete pollination in reducing the seed content of fruits, it has already been shown (Tydeman, 1938), that the variety of pollen used may affect size and seed content. Throughout the earlier stages of development of apple and pear fruits, and more particularly during the June drop period, it is the smaller fruitlets which fall from the tree. In the experiments described, there was a considerable difference in average size between fruitlets on the same tree fertilized by a number of different pollens, and the dropping of the smaller fruitlets meant that a much greater proportion of fruits were lost when pollinated by certain pollens than when other pollens were used.

Not much is yet known about the causes of this so-called June drop but it is most frequently attributed to water shortage during the early summer when the tree presumably needs it most and it is usually most severe in dry summers. But it also occurs from trees in pots where the water supply is controlled, and from trees growing in quite damp situations. It is more severe in some varieties than in others. Cox's Orange is notably subject to it and will drop its fruits in years when other varieties are very little affected. Miller's Seedling frequently sets almost all the flowers on the truss and so do many of the Crabs. In general, however, apple and pear trees do not bring to maturity more than one or two flowers in each truss. It is very commonly thought that the fruitlets which drop during the June drop period are from unfertilized flowers, but observations show that large and apparently quite fertile seeds are contained in even the smallest of such fruitlets.

The evidence of other workers upon the question of the relation between the size or weight and the seed content of mature apples and pears appears to be very conflicting. Brittain and Eidt (1933) could find no definite correlation with the varieties Gravenstein, King, Wagener and Baldwin, while with Spy the correlation was only just statistically significant. Einset (1939) concludes that the correlation varies with locality and season, but Bugini (1938) working with the variety Reinette du Canada, found a consistent increase in average fruit weight with increase in seed content. Southwick (1939) found that fruits of the McIntosh apple with a high seed content dropped earlier than those with a low seed content.

Table I.

Numbers of Seeds Contained in Apples of Different Sizes. Cox's Orange Pippin, Worcester Pearmain and Bramley's Seedling.

	Tree.		No. of Fruits.	Diameters of Fruit in Millimetres.										Average.
				70-66.	65-61.	60-56.	55-51.	50-46.	45-41.	40-36.	35-31.	30-26.	25-21.	20-16.	
Cox's Orange Pippin	A	On the tree	120				8·0	7·1	6·8	6·0	5·7				6·7
,, ,,	A	Dropped	100								7·8	5·7	4·4		6·0
,, ,,	B	Dropped	100								6·4	5·8	5·0		5·7
Worcester Pearmain	A	On the tree	102				9·0	7·7	6·5	5·3	5·1				6·7
,, ,,	A	Dropped	78									4·0	3·6	2·2	3·3
,, ,,	B	On the tree	104				10·0	8·8	7·3	6·4	4·9				7·5
,, ,,	B	Dropped	75									4·8	4·2	2·5	3·8
Bramley's Seedling	A	On the tree	52	5·0	4·0	4·3	4·6	5·2	5·4	4·0					4·6
,, ,,	A	Dropped	109				3·3	4·7	3·5	3·6	4·8				4·0
,, ,,	B	On the tree	60			7·0	6·0	5·3	4·5						5·7
,, ,,	B	Dropped	109					5·8	5·2	4·2	3·0				4·6
,, ,,	C	Dropped	100						6·4	4·4	3·6	1·7			4·0

Table II.

Numbers of Seeds Contained in Apples of Different Sizes. From Trees of Cox's Orange Pippin.

Tree			Number of Fruits.	Diameter of Fruit in Millimetres.							Average number of seeds.	Average diam. of fruit.
				50-46.	45-41.	40-36.	35-31.	30-26.	25-21.	20-16.		
A	Normal June drop	On the tree	53	8·0	7·3	6·8	5·5	5·3	5·0	—	6·19	35·1
	,, ,, ...	Dropped	107	—	—	—	6·1	4·4	3·7	—	4·47	26·8
B	Normal June drop	On the tree	59	6·5	5·6	4·5	4·5	4·0	—	—	4·95	39·0
	,, ,, ...	Dropped	106	—	—	—	4·6	4·6	3·6	4·0	4·31	26·4
C	Severe June drop	On the tree	58	—	7·5	7·3	6·2	6·3	—	—	6·78	34·5
	,, ,, ...	Dropped	121	—	—	—	5·3	4·7	3·9	3·5	4·12	32·6
D	June drop and severe spray damage	On the tree	67	—	6·4	6·9	6·1	6·8	5·0	—	6·43	33·4
	,, ,, ,, ,,	Dropped	110	—	—	6·5	6·9	6·7	5·4	—	6·66	28·5

Observation has shown that the variability in size among the fruitlets on a single tree a few weeks after pollination is extremely great, but it is gradually reduced as the smaller fruitlets fall from the tree in successive waves, throughout the June drop period. Since fruitlet size and seed content appear to be so closely related at this stage, this also means that the average seed content of the fruits remaining on the tree increases correspondingly. Thus, from one point of view the June drop might be viewed as a process by which those fruits are selected which, because they contain the greatest number of seeds, might be supposed to be most useful in the perpetuation of the species.

Summary.—A comparison of fruitlets of Cox's Orange Pippin, Worcester Pearmain and Bramley's Seedling which had fallen during the June drop period with those which remained on the tree showed that there was a very close correlation between fruit size and seed content and that, on the average, the dropped fruits contained fewer seeds.

In two instances in which no correlation could be found, the growth of the fruits was thought to have been affected by insect or spray damage.

References.

Brittain, W. H. and Eidt, C. C. (1933). "Seed content, seedling production and fruitfulness in apples." *Canad. J. Res.*, **9**, 307-33.

Bugini, F. (1938). "Il numero dei semi in rapporto alla grossezza e alla qualita dei frutti nelle nostre piante arboree." *Ital. Agric.*, **75**, 629-33.

Bunyard, E. A. (1912). "The flowers of apples as an aid in identifying varieties." *J. roy. hort. Soc.*, **38**, 234-7.

Einset, O. (1939). "Correlation of number of seeds to weight of fruit in the apple." *Gartenbauwiss.*, **13**, 351-3.

Pearl, R. T. (1932). "The inflorescences of apple trees. Their use in the identification of varieties." *J. Pomol.*, **10**, 19-26.

Southwick, L. (1939). "Relation of seeds to preharvest McIntosh drop." *Proc. Amer. Soc. hort. Sci. for 1938*, **36**, 410-12.

Tydeman, H. M. (1938). "The influence of different pollens on the growth and development of the fruit in apples and pears. I. A progress report on experiments carried out during 1937." *Rep. E. Malling Res. Sta. for 1937*, 117-27.

A PRELIMINARY ACCOUNT OF EXPERIMENTS IN BREEDING EARLY AND MIDSEASON DESSERT APPLES

By H. M. TYDEMAN

Apart from breeding work with apple rootstocks which has already been reported on by Crane, Greenslade, Massee and Tydeman (1936), and Tydeman (1937, 1943), crossings between scion varieties of apples during the past fifteen years have been directed towards the production of new varieties to fulfil certain special purposes. This paper is a preliminary account of the attempt to breed early and midseason apples of good colour and flavour.

With the exception of Beauty of Bath and Miller's Seedling, neither of which is entirely satisfactory, there are no generally approved commercial dessert apples that mature before Worcester Pearmain and the soft fleshed James Grieve. For this reason Worcester Pearmain is often picked long before its proper season and has, as a consequence, been relegated by connoisseurs to an inferior place among apples of quality because of its supposed lack of flavour and character. Nevertheless, it has come to occupy an important position on many farms where dessert apples are grown for market, and it is in many ways an almost ideal market apple. Its bright clear appearance and refreshing juiciness make it easily recognized and keenly sought after by the general public, while its uniform shape and firm skin make it easy to pack attractively and transport without damage.

When apple breeding was started at East Malling one of the first projects to be undertaken was the raising of apples as similar as possible to Worcester, that is, highly coloured juicy summer apples, ripening some weeks before Worcester. As a more distant object it was hoped that ultimately a series of apples could be evolved resembling Worcester in appearance but maturing throughout a large part of the English apple season. Something similar has been attempted with considerable success in Canada with the variety McIntosh Red, and some of the new McIntosh seedlings are being extensively planted there.

The advantages to be derived from the use of such varieties are not difficult to see. The resemblance of their fruits to those of Worcester would ensure a ready sale for them and they could

be picked and marketed over a long period. Packing could be standardized to a much greater extent, and a continuous supply of dessert apples would be available to the public. If, finally, these varieties flowered at much the same time as Worcester, and were interfertile, they might be interplanted and the cultural and manurial treatments could be uniform throughout whole plantations.

Methods.—The crossings were usually carried out on trees in pots under glass and the customary methods were employed. When the seedlings had made from nine inches to a foot of growth, buds from them were worked on to rootstock M. No. IX. It has been established beyond question that the use of a dwarfing and precocious rootstock hastens the fruiting of seedling apples by several years (Tydeman, 1928, 1937). At one or two years from the bud the trees were planted out into their fruiting quarters at 2½ to 3 feet apart in rows 6 or 7 feet apart. They were trained to wire supports and the lower laterals were pruned back to facilitate cultivation between the rows. The seedling trees started to bear flowers and fruit from the sixth or seventh year onwards, much depending on the parentage of the cross and the facility with which fruiting spurs were formed. After a few years' observation it was possible to form a first estimate of the potential value of any particular seedling. Where a fruit was of sufficient merit to warrant further trial use was made of frameworking methods (Garner and Walker, 1938). A plantation of eighteen-year-old bush Lane's Prince Albert on various rootstocks has been set apart for this work, and scions of promising seedlings are stub grafted on to them.

This method of treatment possesses certain disadvantages in that it tends to obscure characters such as the habit of the tree, and also that the intermediate variety may affect the characters of the scion frameworked upon it. Actually, a great deal can be learnt by careful observation about the habit of trees worked in this way although such observations would have to be supplemented later on trees grown in the normal manner. In the present experiments the intermediate variety was in all cases the same, and some well known established varieties were frameworked with the seedlings. Since fruits of these were all quite typical, it may be assumed that those of the seedlings had not been markedly affected by the intermediate.

Actually this frameworking method has proved much superior to any other as a means of obtaining a quantity of fruit quickly. The weights of fruit obtained during the second and third seasons following grafting on three of these seedlings are shown in Table I. All the seedlings yielded almost half a bushel of fruit in the second season while in the third season two of them gave more than two bushels of fruit per tree.

TABLE I.

FRAMEWORKED SEEDLING APPLES. CROP IN LBS. PER TREE.

Seedling No.	Years after grafting.	
	Second.	Third.
431	14	108
432	18	96
435	12	48
Worcester Pearmain ..	16	36

Those seedlings which prove satisfactory under all these tests are submitted for inclusion in the National Fruit Trials at Wisley.

The Material.—Since very little information was available about the inheritance of characters in the apple at the time when this work was started, highly coloured dessert apples were chosen as parents as far as possible, on the principle so generally operative in the plant kingdom that "like will tend to beget like". The greatest use was made of Worcester Pearmain and McIntosh Red, early maturing varieties like Beauty of Bath, Irish Peach and Devonshire Quarrenden, and later maturing kinds such as Wagener, Golden Delicious and Rome Beauty being crossed with them.

In certain instances crosses were deliberately devised to provide information on the inheritance of such characters as fruit colour and shape for guidance in future crossings. For example Devonshire Quarrenden was crossed with the very green fruited Stirling Castle and several of the russets, less with the idea that such combinations would provide the type of apples which were being sought than with that of contrasting parents of widely differing character and of studying the segregation of these variations in their progenies.

In Table II the principal characteristics of the varieties used as parents are tabulated. The descriptions are adapted with modifications from those given by Bunyard (1920).

Table II.

Showing Principal Characters of the Parents Used.

	Season of flowering.	Fruit size.*	Fruit shape.	Fruit colour.	Flavour of fruit.	Juiciness.	Season of maturity.
Baumann's Red Reinette ..	Midseason	2½ by 2¼	round flattened	brilliant crimson	slightly aromatic	juicy	Dec. to Jan.
Beauty of Bath	Midseason	2½ by 1¾	round, much flattened	yellow with red flush and stripes	sweet and pleasant	juicy	early Aug.
Brownlee's Russet	Early	2½ by 2	flat conical	brown green, russet and flush	sub-acid	juicy	Jan. to April.
Cox's Orange Pippin (red sport)	Midseason	2½ by 2¼	round conical	deep crimson flush and russet	excellent	juicy	Nov. to March.
Devonshire Quarrenden ..	Midseason	2½ by 1¾	flat, irregular	covered dark crimson flush	aromatic	juicy	end August.
Golden Delicious	Midseason	2½ by 2¼	round, conical angular	deep golden yellow	sweet and pleasant	juicy	Nov. to Jan.
Golden Russet	Early	2¾ by 2½	round, flattened	golden russet, occasional flush	sugary aromatic	a little dry	Dec. to March.
Irish Peach	Early	2¼ by 1¾	flat, conical	pale yellow, flushed and striped red	aromatic	juicy	August.
Mother (American)	Late	2¼ by 2¼	oval, conical	yellow flushed and striped dull red	very sweet	juicy	Oct. to Nov.
McIntosh Red	Midseason	2¾ by 2½	round, tapering to eye	rich crimson stripes and flush	slightly sweet	juicy	Oct. to Dec.
Rome Beauty	Midseason	3 by 2¾	nearly round	bright red flush and broad stripes	a little sweet; little flavour	juicy	till May.
Rote Sommer Apfel	Early	2½ by 2½	nearly round	brilliant red flush	little flavour	some juice	Aug. to Sept.
Stirling Castle	Midseason	3½ by 2½	round, flattened	pale green	acid	juicy	Sept. to Oct.
Wagener	Early	2¾ by 2	flat, roundish	pinkish, carmine flush and faint stripes	pleasant	juicy	till April.
Worcester Pearmain	Midseason	2½ by 2¼	round, conical	bright crimson on yellow ground	pleasant "strawberry"	juicy	Sept. to Oct.
Yellow Ingestrie	Early	2 by 1¾	square, rounded	golden yellow	sweet	juicy	end Aug. to Sept.

* These dimensions, usually taken from Bunyard, are in inches, the breadth of the fruit coming first.

Table III.

Showing Inheritance of Season of Flowering and Certain Characters of the Fruit in Families of Seedling Apples.

Parentage.	Number of Seedlings.	Season of flowering.			Fruit size.			Fruit shape.			Fruit colour.			Flavour of fruit.			Juiciness.		Season of maturity.			
		Early.	Midseason.	Late.	Large.	Medium.	Small.	Oval.	Round.	Flat.	Entirely coloured.	Partially coloured.	Green.	Sweet.	Sub-acid.	Acid.	Juicy.	Dry.	Summer.	Early Autumn.	Late Autumn.	Winter.
McIntosh Red × Beauty of Bath	11*	6	4	1	0	5	5	0	2	8	3	7	0	4	5	1	8	2	6	3	1	0
McIntosh Red × Worcester Pearmain ..	23	6	16	1	1	17	5	4	11	8	6	15	2	13	8	2	19	4	5	13	5	0
McIntosh Red × Golden Delicious	17	4	13	0	0	11	6	5	3	9	1	16	0	14	2	1	15	2	0	8	7	2
McIntosh Red × Irish Peach	26	12	7	7	1	17	3	6	5	10	3	18	0	14	7	0	18	3	8	12	1	0
McIntosh Red × Wagener	22	11	11	0	4	14	3	1	1	19	5	15	1	13	6	2	18	3	2	9	8	2
Devonshire Quarrenden × Worcester Pearmain	23	0	15	8	0	9	9	3	3	12	6	10	2	8	10	0	14	4	12	6	0	0
American Mother × Worcester Pearmain ..	13	2	6	5	2	7	3	10	1	1	3	9	0	7	5	0	9	3	2	10	0	0
Golden Delicious × Worcester Pearmain ..	9	0	6	3	0	3	3	1	1	4	0	6	0	6	0	0	5	1	2	4	0	0
Rome Beauty × Worcester Pearmain ..	7	0	7	0	1	4	2	0	4	3	0	7	0	1	6	0	3	4	0	5	2	0
Devonshire Quarrenden × Rote Sommer Apfel	77	50	24	3	1	27	8	5	5	26	16	17	3	10	19	7	19	17	31	5	0	0
Devonshire Quarrenden × Yellow Ingestrie ..	83	11	59	13	2	23	39	14	12	38	15	43	6	17	37	10	39	25	45	19	0	0
Devonshire Quarrenden × Stirling Castle ..	130	39	88	3	22	75	17	4	7	103	24	69	21	19	67	28	69	45	60	48	6	0
Devonshire Quarrenden × Golden Russet ..	74	47	25	2	0	27	8	5	5	25	7	25	3	9	17	9	21	14	16	16	3	0
Golden Russet × Devonshire Quarrenden ..	29	19	10	0	0	6	11	5	0	12	3	12	2	6	7	4	16	1	6	10	1	0
Brownlee's Russet × Devonshire Quarrenden ..	19	4	12	3	0	5	4	2	1	6	2	5	2	3	4	2	4	5	1	7	1	0
Baumann's Red Reinette × Brownlee's Russet	30	17	13	0	3	23	2	2	0	26	1	17	10	3	6	19	17	11	0	2	8	18
Cox's Orange (red sport) × Brownlee's Russet ..	27	14	12	1	0	7	9	3	5	8	5	11	0	11	4	1	10	6	5	8	3	0

* A number of seedlings had flowered but not fruited at the time of writing.

Table IV.

Comparison of Seedling Characters and those of the Parent Varieties. Seedling Numbers Expressed as Percentages.

Parentage.	Number of seedlings.	Season of flowering.			Fruit size.			Fruit shape			Fruit colour.			Flavour of fruit.			Juiciness.		Season of maturity.			
		Early.	Midseason.	Late.	Large.	Medium.	Small.	Oval.	Round.	Flat.	Entirely coloured.	Partially coloured.	Without colour.	Sweet.	Sub-acid.	Acid.	Juicy.	Dry.	Summer.	Early Autumn.	Late Autumn.	Winter.
Baumann's Red Reinette	30	57	**43**	0	11	**82**	7	7	0	**93**	**3**	61	36	**11**	21	68	**61**	39	0	7	29	**64**
Beauty of Bath	11	50	**40**	10	0	50	**50**	0	20	**80**	30	**70**	0	**40**	50	10	**80**	20	**60**	30	10	0
Brownlee's Russet	76	**46**	49	5	6	**66**	28	13	11	**76**	14	**64**	22	32	**26**	42	**59**	41	11	32	23	**34**
Cox's Orange Pippin (red sport)	27	52	**44**	4	0	**44**	56	19	**31**	50	**30**	70	0	**69**	25	6	**62**	38	31	50	19	**0**
Devonshire Quarrenden	435	39	**54**	7	8	59	**33**	13	11	**76**	**25**	62	13	**25**	55	20	**62**	38	**58**	38	4	0
Golden Delicious	26	15	**73**	12	0	**61**	39	26	**17**	57	4	96	**0**	**87**	9	4	**87**	13	9	52	**30**	9
Golden Russet	103	**64**	34	2	0	**64**	36	19	10	**71**	20	**70**	10	**29**	46	25	71	**29**	42	50	8	**0**
Irish Peach	26	**46**	27	27	5	**81**	14	29	24	**47**	14	**86**	0	**67**	33	0	**86**	14	**38**	57	5	0
Mother (American)	13	15	46	**39**	17	**58**	25	**84**	8	8	25	**75**	0	**58**	42	0	**75**	25	17	83	**0**	0
McIntosh Red	99	39	**52**	9	7	**69**	24	17	**23**	60	**20**	77	3	**63**	30	7	**85**	15	23	49	**24**	4
Rome Beauty	7	0	**100**	0	14	**57**	29	0	**57**	43	0	**100**	0	14	**86**	0	**43**	57	0	71	29	**0**
Rote Sommer Apfel	77	**65**	31	4	3	**75**	22	14	**14**	72	**45**	47	8	28	**53**	19	**53**	47	**86**	14	0	0
Stirling Castle	130	30	**68**	2	**19**	66	15	3	6	**91**	21	60	**19**	17	59	**24**	**60**	40	53	**42**	5	0
Wagener	22	**50**	50	0	19	**67**	14	5	5	**90**	24	**71**	5	**62**	29	9	**86**	14	9	44	38	**9**
Worcester Pearmain	75	11	**66**	23	6	**60**	34	27	**30**	43	23	**71**	6	**53**	44	3	**76**	24	32	**57**	11	0
Yellow Ingestrie	83	**13**	71	16	3	36	**61**	22	**19**	59	23	68	**9**	**26**	58	16	**61**	39	**70**	30	0	0

Characters of the parent varieties in heavier type.

The Results.—Of the numerous character differences which have been studied on these seedlings only a few of the more prominent and interesting have been selected for brief discussion here. The results for season of flowering and certain characters of the fruit are summarized in Table III in which those families raised primarily for the production of new apples of merit are placed in the upper part of the table and those raised chiefly for the information it was hoped they might provide on the inheritance of characters, below. In Table IV the data have been arranged to illustrate the contribution which each parent variety has made to the inheritance of its seedlings.

Vigour.—Although the methods employed to induce earlier fruiting tended to reduce the natural vigour of these seedlings most of them did not appear to be less vigorous than comparable trees of the parent varieties, although there was a proportion of weak growing seedlings in most families. Under these conditions the parents did not appear to have exerted any marked effect on the seedlings.

Habit.—These seedlings varied greatly in their habit of growth. While most of them formed spurs and well furnished lateral growths very readily, there were a small number in all the families in which the laterals were bare and no spur fruit buds were formed. Although varieties like Irish Peach and Worcester Pearmain, which have a tendency towards this type of growth, were included among the parents there was little definite evidence of any direct influence of the parent variety on the inheritance of this character.

Season of Flowering.—Details of the inheritance of this character are given in Tables III and IV. In general, where early and midseason varieties were intercrossed most of the seedlings were early, and where midseason flowering varieties were crossed together, the larger proportion were midseason. In the only case in which a late flowering variety was used with a midseason kind most of the seedlings were midseason. The inheritance of this character is best illustrated in the summarized form shown in Table V.

TABLE V.

SHOWING INHERITANCE OF SEASON OF FLOWERING.

	Number of Seedlings.	Percentage of Seedlings.		
		Early.	Midseason.	Late.
Early flowering × Midseason flowering ..	387	48	45	7
Midseason flowering × Midseason flowering	220	25	68	7
Midseason flowering × Late flowering ..	13	15	46	39

It is rather remarkable that some late flowering seedlings were obtained in most of the families even where one parent was an early flowering kind and the other midseason.

Colour of the Flowers.—Most of the seedlings had pale pink flowers although white flowered individuals occurred fairly frequently in families of which the whitish flowered Worcester Pearmain was a parent. Seedlings with dark coloured flowers were only found in any quantity in families of which one parent was Brownlees Russet, itself a dark flowered variety.

Foliage Characters.—Details have already been published of the segregation in these seedlings of a character of the foliage which determines susceptibility to damage by sulphur sprays (Tydeman, 1941). Although resistance or susceptibility did not appear to be correlated in any very obvious manner with visible morphological characters of the leaves it was possible to show that the variety Stirling Castle, itself extremely prone to damage by sulphur, transmitted this character to a large proportion of its offspring regardless of the other parent of the cross.

In most of the seedlings the foliage was dark or medium green and seedlings with pale green foliage were only found in any quantity in the family of which Stirling Castle was a parent, where it was apparently related to "sulphur shyness". The leaf surfaces were upfolded along the midrib in almost all the seedlings.

Fruit Characters. (*a*) *Size.*—The size of the fruits of these seedlings was probably influenced to some extent by environmental factors and due allowance has to be made for these in interpreting the records. As Table III shows, large fruits occurred in any quantity only in the family of which the large fruited Stirling Castle was one parent, while the small fruited Devonshire Quarrenden was a parent of most of the families in which any considerable proportion of the seedlings had small fruits. The bulk of the seedlings had medium sized fruits in practically all the families and, as can be seen from Table IV, most of the seedlings with Stirling Castle as one parent had smaller fruits, and most of those with Devonshire Quarrenden as one parent larger fruits than the parent varieties themselves.

(*b*) *Shape.* –In classifying these seedlings on the shape of their fruits for the purposes shown in Tables III and IV, only three classes have been distinguished. Where the fruits were definitely taller than wide they have been described as oval, where they were approximately as tall as wide, round, and where they were wider than tall, flat. Each of these could have been again divided—conical fruits in which there was a distinct taper to the eye being separated from those of approximately equal width all the way up. These latter classes have not been included in the tables.

From Table IV it can be seen that varieties with flat fruits tended to transmit this character to most of their seedlings and in many cases where varieties with round fruits were used most of the seedlings had flat fruits.

(*c*) *Colour.*—Records of fruit colour are summarized in Tables III and IV. At this stage no attempt has been made to enter into the finer differences in fruit colour among these seedlings. The appearance of apples differs not only in the superficial colour which may vary in quantity from the faintest flush to an even and unbroken surface of colour, or in its intensity which may increase from a faint rose pink to a deep purplish blue, but also in the character of the ground upon which these colourings appear ; this may be yellow, creamy white or green. In addition there may be a variable quantity of bloom or a range of degrees of russeting from an almost imperceptible roughness to a thick, hard, scaly surface.

In most of the families every gradation from quite green to completely red apples was found even when one of the parents was not itself a red apple, and in many cases, an almost unbroken series from one extreme to the other could be formed. The quality of the colour seemed to be much more closely related to the variety used as parent. With McIntosh Red, particularly where it was crossed with a highly coloured variety like Worcester, some of the seedlings bore fruits of an almost blue appearance with a profuse whitish bloom. In its more dilute forms the colour was a bright carmine or scarlet, often appearing as a flush or as stripes on a clear, creamy yellow ground. Although usually covered with bloom on the tree, these fruits would very easily take on a brilliant polish. Most of the seedlings with Devonshire Quarrenden as parent, on the other hand, were not particularly attractive, the colour usually taking the form of a dull, rather purplish, red. Even at its most intense it did not approach the bluish tint of some of the McIntosh seedlings, and it was the exception to find much bloom. Quite pretty apples were occasionally found, however, particularly in the family of which Worcester was the other parent.

As Table IV shows most of the seedlings in every family had partially coloured fruits regardless of the character of the parent variety. The green fruited Stirling Castle, when crossed with Devonshire Quarrenden, gave rise to more seedlings with entirely coloured fruits than seedlings with green fruits, while in crosses between red fruited varieties such as McIntosh × Worcester, and Devonshire Quarrenden × Worcester, some seedlings with green fruits occurred. The inheritance of this character is summarized in Table VI.

TABLE VI.

ILLUSTRATING INHERITANCE OF FRUIT COLOUR.

	Number of Seedlings.	Percentage of Seedlings.		
		A. Entirely Coloured.	B. Partially Coloured.	C. Without Colour.
A × A	36	44	49	7
A × B	123	20	65	15
A × C	178	22	63	15
B × B	94	21	76	3
B × C	23	4	96	0

(*d*) *Eye.*—All the varieties used in these crosses have closed eyes except Stirling Castle, in which the eye is open, and Cox's Orange and McIntosh Red in which it is partially open. Most of the seedlings had fruits with closed eyes, but in the families of which Stirling Castle, McIntosh Red and Cox's Orange (red sport) were parents some seedlings with open eyes were found. In the families Baumann's Red Reinette × Brownlee's Russet and Mother × Worcester seedlings with fruits with open eyes also occurred fairly frequently.

(*e*) *Flavour and Juiciness.*—No attempt has been made to enter into the finer differences in flavour among the fruits of these seedlings, and only a very broad classification into sweet, sub-acid and acid has been made in Tables III and IV. Speaking very generally it may be said that seedlings with McIntosh or Worcester as a parent had fruits which were predominantly sweet and juicy, and those with Devonshire Quarrenden as a parent fruits which were sub-acid and often dry. But there

were frequent exceptions. With Stirling Castle, Devonshire Quarrenden produced a relatively large number of seedlings the fruits of which were acid while, with Worcester, almost half had sweet, juicy fruits. McIntosh Red crossed with Beauty of Bath and Golden Delicious, gave rise to seedlings almost half of which had insipid or acid fruits, while in the Baumann's Red Reinette × Brownlee's Russet family about three-quarters of the seedlings had acid fruits.

As Table IV shows, parents with sweet fruits generally, but not always, gave families in which most of the seedlings had sweet fruits. With the acid Stirling Castle and the sub-acid Rome Beauty and Rote Sommer Apfel most of the seedlings had sub-acid fruits.

(*f*) *Season.*—As may be seen from Tables III and IV, early apples appear to have exercised the predominant influence in determining the season of fruit maturity in these seedlings. In the cross between Devonshire Quarrenden and Golden Russet well over 90 per cent. of the seedlings had fruits ripening in summer and early autumn. McIntosh Red × Beauty of Bath and Devonshire Quarrenden × Stirling Castle both produced about 60 per cent. of seedlings with summer fruits while in the cross between the two early apples Devonshire Quarrenden and Yellow Ingestrie almost three-quarters of the seedlings had fruits maturing before mid-September. Only where the two winter apples, Baumann's Red Reinette and Brownlee's Russet were intercrossed, was any quantity of seedlings with late maturing fruits obtained, and it is noteworthy that in this cross seedlings with fruits much earlier than those of either parent occurred.

Practical Considerations.—So far, nineteen seedlings have been selected, after several years' careful test, as likely to prove of value as new dessert apples. They are now growing frameworked on to mature trees of Lane's Prince Albert in the plantation, and two have already been sent for trial in the National Fruit Trials. The parentage of these selected seedlings is as follows :—

McIntosh Red × Beauty of Bath	2 seedlings
McIntosh Red × Worcester Pearmain	4 ,,
McIntosh Red × Golden Delicious	1 ,,
Devonshire Quarrenden × Worcester Pearmain	1 ,,
Devonshire Quarrenden × Yellow Ingestrie	3 ,,
Devonshire Quarrenden × Stirling Castle	1 ,,
Devonshire Quarrenden × Rote Sommer Apfel	1 ,,
American Mother × Worcester Pearmain	1 ,,
Baumann's Reinette × Brownlee's Russet	3 ,,
Cox's Orange (Red sport) × Rote Sommer Apfel	2 ,,

In the more recently raised families the process of selection is being continued as new seedlings come into fruit.

Of all these selections the three which appear most likely at present to prove useful in extending the season during which apples of the Worcester type are available were all derived from the cross McIntosh Red × Worcester. They are perhaps worth describing in some detail, since two of them have already been sent to a few widely separated places in the Home Counties for experimental observation.

No. 431. Fruit of medium size, round slightly conical, bright yellow almost covered brilliant scarlet flush ; flesh white, crisp and very juicy, flavour sweet, pleasant and refreshing. In season during early September. Tree appears vigorous and healthy with dark green foliage. Very similar in season of flowering to Worcester and Cox's, it has shown signs during the present season (1944) of being more frost resistant than Worcester.

No. 432. Fruit of medium size, round to flattish, pale creamy yellow usually entirely covered with a brilliant red flush and a faint white bloom ; flesh white, delicate, sweet and very juicy. In season during October. Tree vigorous and healthy with dark green foliage. In flower at the same time as Worcester and Cox's Orange.

A well-known London firm of fruit salesmen to whom samples of fruit were sent commented as follows :—

" This is of very good quality ; the colouring is attractive, about the calyx it retains some of the characteristics of Worcester but the flesh is more delicate than that of Worcester which from the eating point of view is an advantage but, to offset that, its carrying qualities might not be so good owing to the consequent tendency to bruising.

" To sum up, we consider that this new variety has a promising future before it and should prove very popular with the trade."

No. 435. Of medium size, round or flattish, often somewhat conical, deep creamy yellow usually entirely covered with a deep red flush ; flesh white, crisp and juicy, flavour pleasant and refreshing. In season during November and December. Tree appears only moderately vigorous but healthy, foliage rather pale green but large and healthy. In flower with Worcester and Cox's Orange. Its

most conspicuous faults appear to be a tendency in the fruits to come too dark, and the rather prominent lenticels on the skin. Fruits will keep, however, under quite ordinary storage conditions almost till Christmas.

Discussion.—Since this work was started fifteen years ago, knowledge about the inheritance of characters in apples has been slowly accumulating and, in the light of this more recent research, it is probable that some modification might have been made in the choice of varieties used as parents in some of these families. It is now known that comparatively few characters in the apple are inherited as single units, but are controlled by complexes of genes which give rise to the continuous variation so often encountered in families of apples. Thus, while the combination of parents with highly coloured and early maturing fruits gave the expected preponderance of seedlings with well coloured early fruits, and a greater number of seedlings with later maturing fruits occurred in families of which the parents themselves matured later, a very wide range of variation was found in almost all the characters studied. In practically every cross between red fruited parents some seedlings with entirely green fruits were found and an almost uninterrupted series could often be formed between seedlings with entirely red fruits on the one hand and those with quite green fruits on the other. Another striking example was season of fruit maturity, where crosses between varieties like McIntosh Red, Worcester and Wagener gave seedlings earlier in season of fruit maturity than either parent, and those between varieties such as Devonshire Quarrenden, Yellow Ingestrie and Rote Sommer Apfel in which some of the seedlings had fruits maturing later than those of the parents. Season of flowering affords another example of the same principle; McIntosh Red crossed with Beauty of Bath and with Irish Peach produced seedlings flowering much later than either parent and so also did Devonshire Quarrenden crossed with Rote Sommer Apfel.

While this type of polysomic segregation makes precise genetical analysis extremely difficult and will probably prevent its ever being possible to predict with accuracy the results likely to be obtained from any particular cross, such variability is an asset to the practical breeder of new apples since the field of potential variation is almost indefinitely increased. But in the making of an apple variety worthy to take its place in culture, a large number of good qualities have to be combined, and the coincidence of all these excellencies in a single individual is scarcely likely to be affected by chance. Among these seedlings a by no means negligible proportion were "sulphur shy" and would not have been tolerated in a modern fruit plantation, a further considerable fraction were of an undesirable habit of growth. Of those that remained the larger number had fruits which were too small, too green, too insipid or too dry to be worthy of serious consideration. It is only within the population depleted by the discarding of all such individuals that the breeder can look for the particular combination of desirable characters for which he is searching.

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Summary.—Progress in the work of raising a series of apple varieties similar in appearance to Worcester Pearmain but with varying seasons of fruit maturity is described.

Details are given of the inheritance of a number of characters of the tree, flowers, foliage and fruit, and it is shown that variation is continuous in many instances.

Three selected seedlings thought likely to prove of value as new varieties are described in detail.

References.

Bunyard, E. A. (1920). "A Handbook of Hardy Fruits." Apples and Pears. London. John Murray.

Crane, M. B., Greenslade, R. M., Massee, A. M., and Tydeman, H. M. (1936). "Studies on the resistance and immunity of apples to the Woolly Aphis, *Eriosoma lanigerum* (Hausm.)." *J. Pomol.* **14**, 137-63.

Garner, R. J. and Walker, W, F. (1938). "The frameworking of fruit trees." *Imp. Bur. of Hort. and Plant. Crops.* Occas. Paper No. **5**.

Tydeman, H. M. (1928). "The influence of rootstocks on the blossoming of seedling apples." *Rep. E. Malling Res. Sta. for 1926-1927. II Supplement*, 51-5.

——— (1937). "Experiments on hastening the fruiting of seedling apples." *Rep. E. Malling Res. Sta. for 1936*, 92-9.

——— (1937). "Studies on new varieties of apple rootstocks." *J. Pomol.*, **15**, 165-90.

——— (1941). "The inheritance of susceptibility to sulphur damage in families of seedling apples." *J. Pomol.*, **19**, 137-45.

——— (1943). "Further studies on new varieties of apple rootstocks." *J. Pomol.*, **20**, 116-26.

THE COMPARATIVE SUSCEPTIBILITY OF HIGH- AND LOW-WORKED CHERRY TREES IN THE NURSERY TO BACTERIAL CANKER

By N. H. GRUBB

A NURSERY trial of high- and low-worked trees of Bigarreau Napoleon on seedling " Mazzard " stocks from various sources, and on a vegetatively raised Mazzard stock, the East Malling selection F12/1, completed in 1938, indicated a much greater susceptibility of low- than of high-worked trees to Bacterial Canker. Napoleon has always been very susceptible to Bacterial Canker at East Malling ; but when planning the trial it was hoped that the trees would survive long enough to show whether, and to what extent, vegetatively propagated cherry stocks might be expected to give more uniform trees than seedling stocks. In this respect the trial was designed to give more reliable data than those published in 1925 (Grubb and Witt, 1925). As far as uniformity in growth was concerned, the trial was of little use ; but it did show that the high-worked trees on the vegetative stock were much more uniform in surviving attacks of Bacterial Canker than those on any of the seedling stocks.

The Mazzard F12/1 was selected from a number of cherry stocks sent to East Malling by a northern nursery firm early in 1917, under the name of " Mazzard " ; stocks of another lot from the same firm, called " Common " cherry, were in most respects very similar ; all were sweet cherries, the botanist's *Prunus Avium*. Close observation showed that all the stocks in each collection were distinct individuals ; they may have been seedlings raised by the senders or obtained by them from trade sources ; or they may have been " wildings ", dug from woods and hedgerows. It seems likely that the firm who supplied them would have had rather few opportunities of obtaining wildings in their locality, and therefore that the plants were ordinary commercial seedlings ; but there is nothing to rule out the possibility that they were wildings.

The collections of seedlings numbered F230, F231 and F232 were raised from seed kindly sent to East Malling by Professor R. D. Anthony, of State College, Pa., U.S.A., with a note that each came from an individual wild tree in Pennsylvania. F260 was a collection of commercial seedlings obtained from an English trade source. It seemed clear that the plants in each collection varied considerably, but that in F260 the variation was greater than in the other three. There were, in fact, group differences in the three lots from Pennsylvanian seed, which seemed to extend even to their susceptibility to Bacterial Canker.

The stocks were planted in units of 16, in five randomized blocks. Eight of each unit were budded near ground level in the summer following planting (1933), and the remainder grafted at about 6 feet from the ground in the spring of 1936. A very satisfactory proportion of both buds and grafts grew, and previous to infection by Bacterial Canker their growth was vigorous and healthy.

The accompanying Table shows the extent to which the various sets of trees were killed by Bacterial Canker.

	Seedling Stocks.											
	F12/1.		F230.		F231.		F232.		F260.		All	
	High.	Low.	High.	Low.	High	Low.	High.	Low.	High.	Low.	High.	Low.
Grafts or Buds successful out of 40 ..	39	38	39	35	39	36	40	40	40	39	197	188
Dead by March, 1937 ..	0	23	1	20	4	14	7	18	2	17	14	92
Dead by March, 1938 ..	1	–*	10	–*	14	–*	11	–*	8	–*	–	–*

* Trees grubbed 1937.

High- v. Low-working.—The very much heavier mortality amongst the low-worked trees up to March, 1937, is well shown ; it amounts to nearly 49 per cent., as compared with just over 7 per cent. for the high-worked trees. Analysis shows that the difference is highly significant.

Vegetative v. Seedling Stocks.—In March, 1937, the differences in mortality between the trees on F12/1, and those on seedling stocks, whether high- or low-worked, were slight and quite without significance. A year later, however, after all the low-worked trees had been removed owing to the heavy damage they had suffered, the high-worked trees showed a very much lower mortality on F12/1 than on any of the four sets of seedling stocks—under 2·6 per cent. as compared with an average of over 27 per cent. Analysis shows that this difference also is significant.

Discussion.—The large difference in mortality between high- and low-worked trees here shown indicates that the Napoleon stems were more susceptible to infection by Bacterial Canker than those of the stocks " run up ". It has long been found at East Malling that young trees of Napoleon are amongst the most susceptible of all varieties in the variety collection ; and Mazzard F12/1 has proved very much more resistant. The evidence given here shows that on the average the seedling stocks must also have been more resistant, and points to the commercial advantage of high-working, especially with very susceptible cherry varieties.

Since infections are known to occur chiefly in late autumn and winter (Wormald, 1938) and are not readily visible by March, when these records were made in 1937, it was inevitable that the high-worked grafts with only one year's growth would not show any large proportion infected. A year later, March, 1938, when the high-worked grafts had made two years' growth, the number of obvious infections might be expected to be larger, as most of them would be more than a year old by that time. The positions of the cankers were not, however, recorded in detail and both for 1937 and 1938 it is impossible to state whether the cankers occurred in the Napoleon scion or in the rootstock stem-piece. The fact that by 1938 significantly fewer trees on F12/1 had been killed than on seedling stocks does not necessarily mean that F12/1 imparted any marked resistance to the scion, though it may have done so to some extent, for it may also mean that the stems of F12/1 were uniformly less susceptible to attacks by this disease. Whatever the reason, however, it may be concluded that trees on the vegetatively propagated Mazzard F12/1 were significantly more uniform in surviving the attacks of Bacterial Canker than the seedling Mazzards, which showed great variation in this respect.

Acknowledgements.—The writer would like to express his thanks to the East Malling Propagation Section for their very successful work in raising the stocks and trees for the trial here described ; to several members of the Staff who recorded the data used ; and to the Statistical Section for their analysis of the data.

Summary.—Low-worked trees of Bigarreau Napoleon cherry in the nursery are here shown to have been significantly more injured by Bacterial Canker when three years old from the bud than high-worked trees one year old from grafting. At two years old from grafting there was significantly less injury to the high-worked trees where the stocks were the vegetatively propagated selection F12/1, than where they were stocks raised from seed from any one of four sources. The implications of these differences are discussed.

References.

Grubb, N. H. and Witt, A. W. (1925). " Cherry Stocks. Their Behaviour in the Nursery." *Rep. E. Malling Res. Sta. for 1924*, 87-92.

Wormald, H. (1938). " Bacterial Diseases of Stone-fruit trees in Britain. VII. The Organisms causing Bacterial Canker in Sweet Cherries." *J. Pomol.*, **16**, 280-90.

OUTDOOR TOMATO VARIETY TRIAL, 1943

By W. CORBETT (Advisory Officer K.W.A.E.C.) and H. M. HUGHES

By arrangement with the Horticultural Sub-Committee of the Kent War Agricultural Executive Committee, a variety trial of outdoor tomatoes was carried out in the walled garden attached to Bradbourne House, East Malling Research Station. A duplicate trial was also carried out at the K.E.C. Glasshouse Demonstration Station at Wilmington. The trial at East Malling was on a rich garden soil which had not previously carried a tomato crop ; that at Wilmington was on a light, sandy loam which had carried tomato crops in the two preceding years.

The experiments were laid out in four randomized blocks of nine plots. The varieties grown were Ailsa Craig, Early Market, Earliest of All, Vetomold, Harbinger, Hundredfold, Market King, Radio and X-Ray. The preparation of the land for the crop in both instances was the same, except that at Wilmington an intercrop of lettuce was taken. The manurial treatment consisted of a dressing of farmyard manure, 2 cwt. per acre of muriate of potash, 3·3 cwt. per acre of superphosphate and 6 cwt. per acre of meat and bone meal. The fertilizers were applied and harrowed in a few weeks before planting.

Plants for both experiments were raised in 3 in. pots at the K.E.C. Glasshouse Demonstration Station, and were planted 15 in. apart in rows 3 ft. apart on 25th May. Planting conditions were good and all the plants got away well. In the experiment at East Malling a certain amount of " Foot-Rot " occurred, especially in the variety X-Ray. The plants were supported by string attached

at one end to the base of the plant with the other end tied to a wire stretched along the rows and supported on 4 ft. 6 in. posts. All plants were stopped on 11th August at two leaves above the last truss to show set fruit. Dusting with a copper-lime dust for "Blight" control was carried out from the last week in July at fortnightly intervals until the middle of September. The season was unfavourable to the spread of this disease and it was not observed on the plants. Almost every plant in the Wilmington trial was severely affected sooner or later with "Enation Mosaic" disease, which may account for the considerable differences in yields between the Bradbourne and Wilmington experiments. At Bradbourne this disease occurred to a lesser degree and the few most severely affected plants were removed which, with those lost through "Foot Rot" accounts for most of the losses as shown in the first column of Table I. "Blossom-drop" occurred on all varieties during July. There was also some Blossom End Rot on all varieties, Earliest of All being the most affected. Both these disorders are occasioned by dry soil conditions. In both experiments watering was done with

Table I.

Outdoor Tomato Variety Trial. Bradbourne, 1943.

Crop Summary.

Variety.	Number of Plants out of 400.	Ripe Fruit.				Green Fruit.		Total Crop.	
		Average Crop in lb. per plant			Tons per acre.	lb. per plant.	Tons per acre.	lb. per plant.	Tons per acre.
		July and Aug.	Sept.	Total.					
1. Harbinger	378	1·49	1·76	3·26	16·9	1·55	8·0	4·81	24·9
2. Earliest of All	368	1·53	1·62	3·14	16·3	1·10	5·7	4·24	22·0
3. Ailsa Craig	384	1·03	1·99	3·03	15·7	1·37	7·1	4·40	22·8
4. Vetomold	371	1·40	1·51	2·91	15·1	0·76	3·9	3·67	19·0
5. Market King	344	1·20	1·70	2·90	15·0	1·47	7·6	4·37	22·6
6. Early Market	371	1·08	1·74	2·82	14·6	1·75	9·1	4·57	23·7
7. Hundredfold	369	1·10	1·67	2·78	14·4	1·57	8·1	4·35	22·5
8. Radio	373	0·85	1·79	2·64	13·7	1·61	8·3	4·25	22·0
9. X-Ray	316	0·59	1·58	2·17	11·2	2·02	10·5	4·19	21·7
Sig. Diff. P = ·05 ..		0·15	0·26	0·30		0·45		0·47	

Note: Figures are based on a 15″ × 3′ plant giving 11,616 plants per acre.

Table II.

Outdoor Tomato Variety Trial. Demonstration Station, Wilmington, 1943.

Crop Summary.

Variety.	Ripe Fruit.					Green Fruit.		Total Yield	
	Average Crop in lb. per plant.				Tons per acre.	lb. per plant.	Tons per acre.	lb. per plant.	Tons per acre.
	Aug.	Sept.	Oct.	Total.					
1. Market King	0·83	1·25	0·17	2·25	11·65	0·91	4·71	3·16	16·36
2. Harbinger	0·88	1·10	0·16	2·14	11·08	0·70	3·63	2·84	14·71
3. Earliest of All	0·94	1·02	0·16	2·12	10·98	0·71	3·67	2·83	14·65
4. Early Market	0·66	1·12	0·18	1·96	10·15	0·93	4·82	2·89	14·97
5. Radio	0·52	1·12	0·20	1·84	9·53	0·91	4·71	2·75	14·24
6. Hundredfold	0·46	1·06	0·16	1·68	8·70	0·83	4·30	2·51	13·00
7. Vetomold	0·44	1·06	0·15	1·65	8·55	0·69	3·57	2·34	12·12
8. Ailsa Craig	0·37	0·85	0·15	1·37	7·09	0·98	5·08	2·45	12·17
9. X-Ray	0·24	0·83	0·09	1·16	6·01	0·75	3·88	1·91	9·89
Sig. Diff. P = ·05 ..	0·15	0·35*	0·09*	0·43		0·25*		0·63	

* Note: Apparent Sig. Diffs. between extreme values cannot be relied on.

overhead irrigation spray lines. Splitting of fruit occurred on all varieties and it is possible that late application of water may have been a contributory factor.

Picking in quantity was started at both places the first week in August, and continued until 24th September at Bradbourne and until 5th October at Wilmington. On these dates all fruit was picked and the green fruit of marketable size was taken into glasshouses for ripening.

Results.—The cropping figures for these experiments are shown in Tables I (Bradbourne) and II (Wilmington). In both Tables the varieties are set out in order of total ripe fruit picked. The yields are calculated on the basis of weight of marketable fruit per plot. No allowance is made for plants which died or were removed, so that the total yield is much reduced in some varieties, for example X-Ray and Market King at Bradbourne, where there was a high mortality due to Foot Rot and severe "Enation Mosaic". The number of plants which survived in the Bradbourne experiment is shown in Column 1 of Table I. Although no records of this nature were kept for the Wilmington experiment the mortality was much lower than at Bradbourne since, as stated earlier in this paper, the few plants severely infected with "Enation Mosaic" were removed from the Bradbourne plots, whereas no such plants were removed from the Wilmington plots, indeed had this been done almost every plant would have been removed. The high percentage of affected plants probably accounts for the very much higher plot to plot variation in yield at Wilmington.

From an examination of the two Tables it will be seen that two varieties, Harbinger and Earliest of All, occur in the first three in both experiments, and it is possible that, if the mortality rate of the variety Market King had not been so high in the Bradbourne experiment, the first three varieties in both Tables would have been the same, namely Market King, Harbinger and Earliest of All. The remaining varieties gave varying results.

So far as the amount of green fruit is concerned there was considerable varietal difference and it does not appear possible to correlate this with any other factor. It will be noted in both trials that X-Ray had significantly the most unripe fruit. It does suggest, however, that if conditions obtained which allowed for a longer cropping period the results based on weight of ripe fruit might be considerably different.

Two varieties, Harbinger and Earliest of All, gave outstandingly the earliest fruit of all varieties, except Market King, which equalled them in the Wilmington experiment. X-Ray gave the lowest yield of ripe fruit in August for both experiments. These are the only statistically significant differences in earliness.

The varying results of the varieties other than Harbinger and Earliest of All, and possibly Market King, lend support to the generally acknowledged statement that tomato varieties must be chosen to suit the particular type of soil, especially in relation to shape and size of fruit.

The fruits of two varieties, Earliest of All and Vetomold, were all of uneven shape and size in the Bradbourne experiment and had the most split fruit, whilst at Wilmington the fruit of these varieties was reasonably even in shape. All other varieties gave fruit of even shape and good size except Harbinger, which, at Bradbourne, produced fruit which was rather small.

Discussion.—In the production of outdoor tomatoes under wartime conditions total yield and firmness of fruit are probably the most important factors, whereas under normal peacetime conditions considerable regard should be paid to the additional factors of quality of fruit as expressed in terms of shape and evenness of colouring. A further very important factor is the earliness of the crop, for it will be easily seen that, apart from the probable increase in ultimate cash return, there will be a longer picking period which will materially assist in eliminating possible glut periods.

It should also be borne in mind that the selection of suitable varieties alone will not ensure good crops. Weather conditions will not only affect cropping in general, but may also affect the cropping capacity of certain varieties in different seasons. The type of plant used for planting in the open has considerable influence on the ultimate yield. To obtain the best results the plants should be well acclimatized to outdoor conditions, and be strong, well balanced plants with a large, clean root system; they should not be hard and should have the first truss showing in the head.

To base conclusions on one year's experiments would be unwise, but the results obtained indicate that the three most promising varieties are Harbinger, Earliest of All and Market King.

Acknowledgements.—Acknowledgements are due to Mr. T. N. Hoblyn of the Statistical Section at East Malling for the lay-out of the trials and the examination of the results; and to the Kent Education Committee for permission to publish the results of the trials carried out at the Glasshouse Demonstration Station, Wilmington.

Summary.—Trials of nine varieties of tomato for outdoor culture were planted at Bradbourne, East Malling, and Glasshouse Demonstration Station, Wilmington. Records are given of the monthly totals of ripe fruit and the total yields of each variety. The relative values of nine varieties are discussed and certain recommendations made. The importance of other factors to be considered in outdoor tomato growing is stressed.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1943.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	28 years' average.	Total Hours.	Average per day.	28 years' average.	4 inches.	8 inches.	2 feet.
January	47	35	56	23	41	12	4·96	1·06	2·48	39·3	1·3	46·2	38·5	39·4	40·9
February	49	35	58	23	42	14	1·50	0·47	1·85	80·7	2·9	67·0	38·6	40·4	42·0
March ..	53	41	61	29	47	24	0·33	0·22	1·62	129·4	4·2	118·9	40·9	42·0	42·9
April ..	60	44	77	32	52	3	1·51	0·61	2·04	152·9	5·1	130·3	51·1	50·2	50·1
May ..	65	44	84	37	54	0	2·82	1·01	1·79	251·8	8·1	195·2	57·1	55·5	55·6
June ..	68	48	76	41	58	0	1·68	0·28	1·43	211·9	7·0	208·3	62·4	61·0	61·3
July ..	71	52	90	44	61	0	1·40	0·44	2·21	196·6	6·3	192·6	64·4	62·9	63·4
August ..	72	52	82	42	62	1	2·74	0·60	2·20	204·2	6·6	180·1	64·3	63·7	64·9
September	66	45	77	31	55	1	2·38	0·68	2·05	154·1	5·1	147·2	56·6	57·3	60·3
October	60	45	68	32	52	1	2·91	0·92	2·72	89·9	2·9	100·3	51·4	52·1	54·6
November	49	36	58	27	42	13	1·49	0·27	3·16	60·8	2·0	53·5	41·8	43·1	46·9
December	44	33	50	26	38	16	1·96	0·97	2·70	33·9	1·1	38·7	37·2	38·1	40·9
Totals						85	25·68		26·25	1605·5		1478·3			

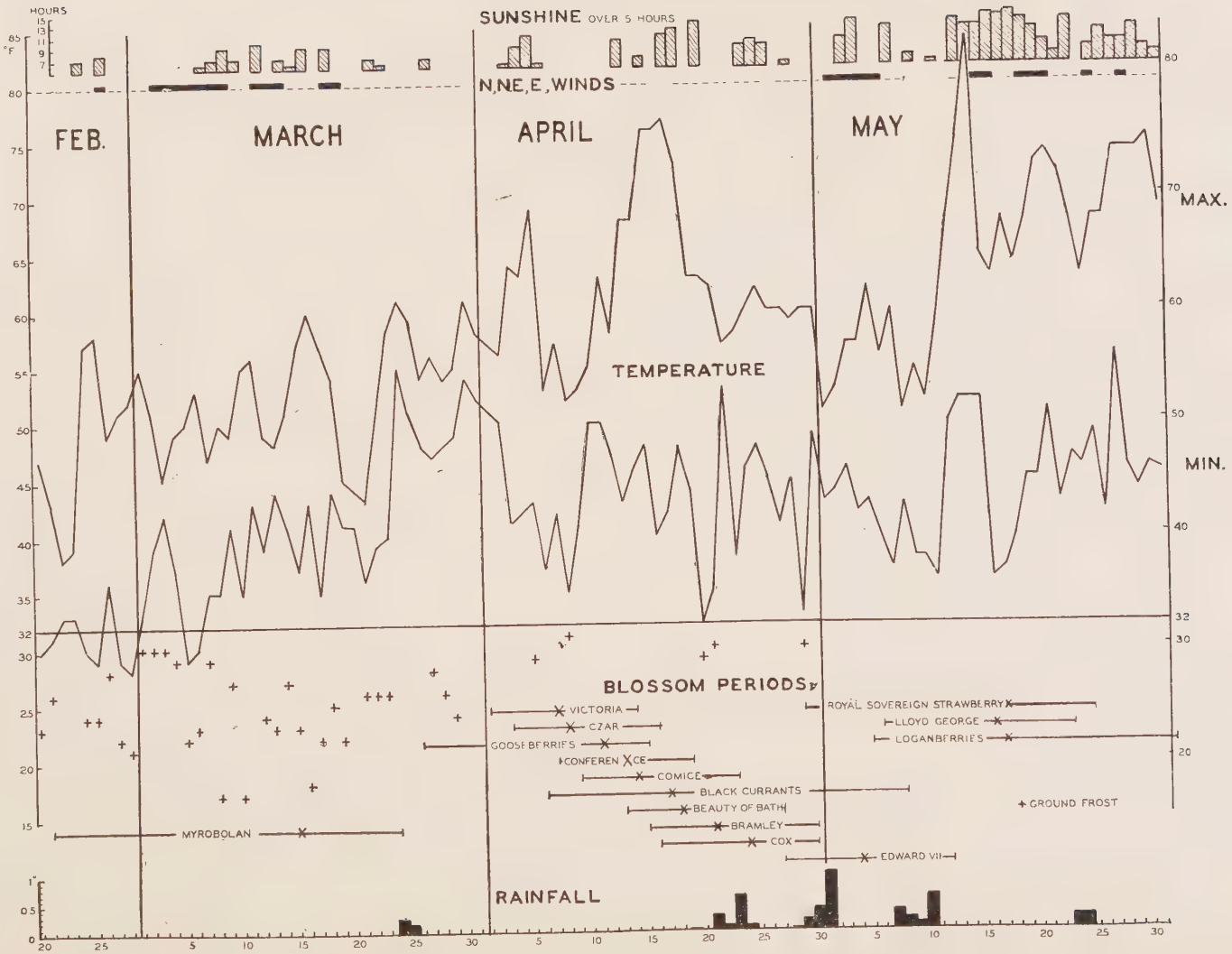


Diagram to show the Weather recorded during the Blossoming Season 1943.

WEATHER CONDITIONS DURING 1943

By H. C. CHAPELOW and H. M. TYDEMAN

ALTHOUGH the weather during 1943 was very normal in many ways, it presented several features of interest. Abnormally warm conditions during the first three months of the year resulted in an unusually early blossoming season of all kinds of hardy fruits, which were able to set in very favourable weather. In spite of the fact that the Myrobolan plum was in blossom during late February and March when ground frosts were very numerous and often severe, as may be seen from the Diagram,* a good crop was secured. Throughout April and May when most of the fruits were in flower, although the weather was cool, sunshine was plentiful and ground frosts absent.

Taking the year as a whole, rainfall was only slightly deficient. Although March and April were exceptionally dry, very wet conditions during January and again in May ensured that ample supplies of moisture were available for plant growth. During November and December rainfall was almost 2½ inches less than the average for those months, and this dry period has been prolonged in this locality throughout the first half of 1944. Although there is a widespread belief that the weather has gradually been getting drier during the past few years, it is not borne out by the records here. The average annual rainfall during the past five years was 27·58 inches, while the average annual rainfall for the past 28 years was 26·25.

The total sunshine for the year was 1,605½ hours, or more than 100 hours in excess of the average here. May and August were outstandingly sunny months while October had rather less sunshine than usual.

PLANT PHYSIOLOGY

FURTHER TRIALS WITH SPRAYS TO CONTROL PRE-HARVEST FRUIT DROP

By M. C. VYVYAN

FURTHER work on the use of hormone sprays to control fruit drop was carried out in 1943 and this note is a progress report on the results.

Worcester Pearmain.—Four rows, each of eight mature trees, were used in a trial with alpha-naphthalene acetic acid. As this was designed more as a demonstration than as an experiment, the lay-out was made as simple as possible; the two centre rows were sprayed and the two outer left unsprayed as a control. The spray was applied on the 17th August at the "standard strength" of 10 parts per million and about 5 gallons were put on each tree. The fruit were picked, three weeks later, on the 7th September. All drops were removed from under the trees at the time of spraying, and subsequent drops from each tree were collected at intervals of two or three days, sorted into "good" and "bad", counted, and the weight of the "good" determined. The final collection consisted of the fruit that dropped in the course of picking. The fruit picked from each tree were counted and weighed.

The main results are summarized in Table I. The average number of bushels picked per tree was 4·73 from the sprayed and 2·96 from the controls. Thus the sprayed trees lost about one and three-quarter bushels less per tree than the controls. This difference between sprayed and controls was partly due, however, to there happening to be a larger proportion of bad apples on the controls than on the sprayed. When the actual values are adjusted for the difference in total weights of apples, the reduction of drop as a result of spraying works out at 1·46 bushels. A loss of a bushel and a half of apples is obviously thoroughly well worth preventing and would give a handsome profit after paying for the expense of spraying. Moreover, 1943 was an early season, and the picking of the other Worcesters on the Station began on 12th August—about a fortnight earlier than usual—and ended on 3rd September. Thus the fruit on the sprayed trees in the trial were kept on the trees throughout the three-week picking season and for four days beyond it, with a loss of less than half a bushel out of a crop of five bushels per tree. The use of this spray on Worcester can, therefore, be thoroughly recommended, to reduce loss during the picking period and permit the period to be prolonged.

Bramley's Seedling.—Observations in 1942 indicated that considerable drop may occur in this variety several weeks before time for picking. This suggested that an early growth substance spray

* The writers are indebted to Mr. T. N. Hoblyn for permission to reproduce the diagram which he prepared.

Table I.

Worcester Pearmain.

Sixteen control trees and sixteen sprayed with 10 parts per million alpha-naphthalene acetic acid, 5 gallons per tree, on 17th August, 1943. Fruit picked on 7th September.

			Control.	Sprayed.	Difference (Sprayed-Control).
Numbers of Fruit (16 trees)	On trees, 17/8		18348	18976	+ 628
	Drops, 17/8 to 7/9	Bad	2463	962	− 1501
		Good	5723	1485	− 4238
	Picked 7/9		10162	16529	+ 6467
Weights (lb.)	Good drops		1154·2	272·9	− 881·8
	Picked		1893·7	3012·5	+ 1118·8
Bushels (40 lb.) Good Fruit per tree.	Actual	Drops	1·80	0·43	− 1·37
		Picked	2·96	4·73	+ 1·77
	Adjusted	Drops	1·87	0·41	− 1·46
		Picked	3·07	4·53	+1·46

combined, perhaps, with the last lead arsenate codling moth spray, might be of value. Accordingly, on 21st June, 1943, fourteen mature trees of Bramley were sprayed with lead arsenate at 2 lb. per 100 gallons plus 7½ parts per million alpha-naphthalene acetic acid, and fourteen similar trees received lead arsenate alone. About 3½ gallons were applied to each tree. By 10th September the one set of trees had lost about 3 per cent. of their good fruit, the other about 34 per cent. The gain, even if significant, was too small to be of value. On 9th September seven trees in each batch of fourteen were given a further application of growth substance at the same concentration, but without lead arsenate. The fruit was picked three weeks later on 30th September and averaged a little over seven bushels per tree. Very little drop occurred in the interval; the sprayed trees lost about 3 per cent. of their remaining fruit, the controls about 7 per cent. Owing to this low rate of drop, the results are inconclusive. Spraying Bramley with growth substance cannot be recommended on the strength of these trials, but it must be remembered that the concentrations used and the quantities put on each tree, though found adequate for some varieties here, are considerably lower than those usually recommended in the U.S.A. It is possible that a concentration of 10 parts per million, put on at the rate of one and a quarter gallons per bushel of fruit might prove of value in a year of heavy drop.

Conference Pear.—A spray of 5 parts per million alpha-naphthalene acetic acid was compared with a commercial product, used at an equivalent concentration, in a trial with Conference pear. There were ten mature trees under each treatment and ten left as a control. The sprays were applied on 16th August and the fruit was picked 10th September. Less than 5 per cent. of the fruit dropped under any treatment or the control, so the results were inconclusive. In the previous season this variety showed a considerable drop.

Cox's Orange Pippin.—Some top-worked Cox's, of rather variable size and crop, were used in an experiment on the effect of combining growth substance with an oil spray. Eleven trees received oil plus growth substance, eleven oil alone and eleven were used as controls. The sprays were applied on 12th July and the fruit were picked on 17th September. Very few fruit dropped during the first month, so the results were not conclusive.

Summary.—In 1943, which was an early season, a spray of 10 parts per million alpha-naphthalene acetic acid, was applied, at the rate of about five gallons per tree, to Worcester Pearmain apple trees on 17th August, five days after the picking season for this variety had started. The spray considerably reduced drop during the three-week picking period and allowed the period to be prolonged for a further four days. Out of a crop of about 200 lb. (five bushels) per tree, the sprayed trees lost less than half a bushel per tree in three weeks, whilst the unsprayed controls lost nearly two bushels.

Spraying this variety to reduce loss during a prolonged picking period can therefore be thoroughly recommended.

Addition of the same substance at $7\frac{1}{2}$ parts per million to a lead arsenate codling moth spray, applied rather thinly to Bramley Seedling in June, had little effect in reducing drop.

BIOCHEMISTRY

ABNORMAL RIPENING OF CHERRIES

By S. G. THOMPSON

A VERY large and apparently healthy Caroon cherry tree, growing in an orchard at Malling Heath, where other trees showed symptoms suggesting trace element deficiencies, set a full crop in 1943, and the fruit developed normally until just before picking, when the cherries failed to fill out and became hard, shrivelled and blotchy ; the condition was so bad that no cherries from this tree could be marketed. The grower stated that this tree had consistently produced large crops for many years, that he had not noticed the trouble before, and that he did not know of any similar case.

Analysis showed that leaves from this plantation contained an abnormally low amount of boron, suggesting that the abnormal behaviour might be due to a deficiency of boron, and in March, 1944, the soil of half the area of the overhang of the branches was given a dressing of $1\frac{1}{2}$ lbs. commercial borax. The drought of spring and early summer was unfavourable for a soil dressing to take effect, but during May and June the foliage on the treated side appeared to be larger and of slightly darker green than that of the untreated side. At the end of June the symptoms noted in 1943 appeared in a less severe form which did not prevent marketing : on the treated side of the tree cherries ripened earlier and approximately 20 per cent. showed signs of the abnormality, against approximately 80 per cent. on the untreated side.

No final conclusions can be drawn from a single result of this kind and the evidence is not sufficient to prove boron deficiency ; but should such abnormalities prove to be widespread this simple, inexpensive soil treatment would be worth trying.

Boron deficiency is important in sugar beet in some areas in this country and very serious in apples overseas (producing the disease known as " Internal Cork "), but there is so far no known example in fruit in this country.

As further information about this disorder in cherries is desirable, growers who have noticed abnormal ripening of cherries similar to the case described are requested to report it to this Station for investigation.

Summary.—A cherry tree, on which the fruit just before maturity became hard, shrivelled and blotchy in 1943, showed improvement in 1944 after boron treatment.

PLANT PATHOLOGY

SILVER LEAF AND PAPERY BARK IN APPLE TREES

By H. B. S. MONTGOMERY and H. WORMALD

A RECENT paper by one of us (Wormald, 1943) describes the association of papery bark cankers and the Silver Leaf fungus, *Stereum purpureum*, in grafted apple trees. Field observations suggested that the hard cutting-back in top-grafting favoured the formation of papery bark and also infection by the fungus. Some experimental evidence was offered, but up to that time the experiments had not shown definitely whether papery bark was wholly a result of cutting-back or if the fungus was a contributory factor. An experiment here described was designed to throw light on this question.

Nine Newton Wonder apple trees (five years old) growing in the open plantation were cut back to different levels.

Three were cut back hard, the whole head being removed.

Three had all their branches cut back to about six inches of the crotch as in ordinary topgrafting.

Three had one branch only cut back, to about six inches of the crotch, on each tree.

In each set of three, two trees were inoculated by placing small pieces from prune agar cultures of *Stereum purpureum* (isolated from the wood of an apple tree) on the cut ends, which were then

covered with moist sterile cotton wool, and cellophane over the cotton wool. The third, control tree, was treated similarly, but sterile agar only was put on the cuts.

The inoculations were made on 18th May, 1943, and the cellophane was removed on 8th June. The trees were examined in August and September for symptoms showing in summer, and again in winter for final results.

The control trees all produced healthy shoots with no trace of Silver Leaf and no infection of the wood ; the tree with the whole head removed, and the one with all the branches cut back to 6 in. showed, at the end of the experiment, papery bark for 2½ in. and 2 in. respectively, while the tree with only one branch cut back showed no papery bark.

The trees inoculated with the fungus all became infected, the degree of infection depending on the degree of cutting-back. There was no appreciable difference between those with heads completely removed and those with all the branches cut back ; during the summer all showed pronounced Silver Leaf and a little papery bark just below the cuts ; in winter there was papery bark along the whole stem and there were many fructifications of *Stereum purpureum* from the crotch to ground level. In the two inoculated trees with only one branch on each cut back there was no papery bark in summer and only a trace of Silver Leaf on one of them ; in winter they showed papery bark for 2 in. below the cut surface ; no fungal fructifications were present, but the wood near the pith showed the discoloration typical of infection by *S. purpureum*, extending in both as far as the crotch and in one of them for one foot into the stem.

The normal course of infection by *Stereum purpureum* is for the fungus to spread most rapidly in the wood near the pith, seldom invading the outer layers of the wood until the vigour and health of the tree has been greatly diminished. Thus the infected wood in a tree may extend from ground level right up into the branches without approaching closely to the bark at any point. The resistant nature of these newly formed layers of wood was first reported by Brooks (1913), and was obvious, in the experiments described in the present paper, in those trees where only one branch was cut back. When, however, trees were severely cut back, not only did the fungus travel readily down the wood near the pith, but it also spread out into the younger layers of wood so that the cambium and bark were also killed. Thus hard cutting back appeared to lower the resistance of these layers of wood to this fungus.

These results show that severe cutting back was an important predisposing factor in causing papery bark and that while the condition was produced to a very slight extent in the absence of *Stereum purpureum*, it was far more pronounced and extensive where hard cutting back was combined with infection by the fungus through the cut surface.

The results emphasize the conclusion drawn in the previous paper, that the risks of loss from grafting as a result of papery bark and Silver Leaf in apple trees can be reduced by using a modern frameworking method (involving comparatively little cutting-back and no large, easily infected, cut surfaces) in preference to the ordinary " top-grafting " of the past, when converting one variety of apple tree to another.

Summary.—An experiment is described in which Silver Leaf, followed by severe papery bark and later the appearance at the surface of the stems of fructifications of the fungus, resulted from hard cutting-back and inoculation of the cut surfaces with *Stereum purpureum*. Cutting back of only one branch resulted in but slight infection and little papery bark. Control trees showed a little papery bark and no infection.

References.

Brooks, F. T. (1913). " Silver-leaf Disease (II)." *J. agr. Sci.*, **5**, 288-308.

Wormald, H. (1943). " Papery Bark Canker of Fruit Trees in Relation to Silver Leaf Disease." *J. Pomol.*, **20**, 144-6.

VERTICILLIUM WILT OF PLUM

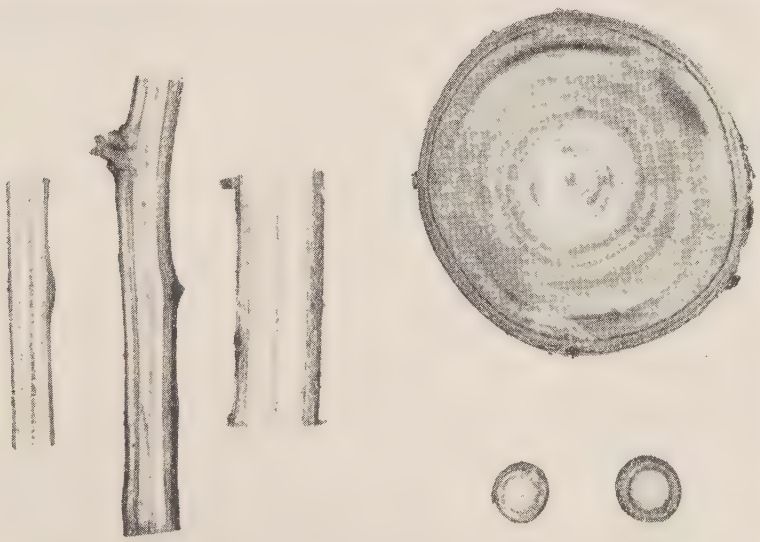
By W. G. KEYWORTH

Toward the end of July, 1943, symptoms of wilt were seen on a six-year-old plum tree (var. Victoria) growing on a fruit and hop farm at Hunton, Kent.

The older leaves on all the branches were withered and dead, and many branches were almost entirely defoliated. The young leaves were wilted and yellowish-green, and a few wilted and prematurely reddened fruits were still present. Transverse sections of the main stem at one foot from the base showed three or four irregularly crescent-shaped brown areas in the wood. This discoloration could be traced up the wood as far as the youngest branches, which were some 10-12 feet from the

FIG. 1.
Plum tree infected with *Verticillium albo-atrum*.

FIG. 2.
Transverse and longitudinal sections of main stem and branches showing discoloured wood.



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ground, and where it was evident as a dark brown ring just below the phloem tissue. Fig. 1 shows the field symptoms and Fig. 2 the appearance of sections of the wood.

Isolations were made from the discoloured wood of the branches and a species of *Verticillium* was obtained which, when grown in culture on prune agar, developed dark hyphae but produced no microsclerotia. It was identified as *Verticillium albo-atrum* Reinke and Berth., and appeared morphologically identical with isolates of this species obtained from hops on the same farm affected with Verticillium Wilt (Keyworth, 1942).

Verticillium Wilts of several varieties of plum have been recorded by Czarnecki (1923), Dufrenoy and Dufrenoy (1927), and Rudolph (1926). From the descriptions given it appears that in each case the pathogen was a microsclerotial form of *Verticillium*—probably *Verticillium Dahliae* Kleb.

It seems probable that the plum tree seen on this farm had become infected from wilted hops as follows:—

In August, 1942, an outbreak of Verticillium Wilt was noted in a hop garden on the farm and as a precaution against further spread of the disease, the infected bines were pulled down and carried to the plum orchard where the usable hops were picked from them. Some of the bines were inadvertently left around the base of the plum tree and remained there throughout the following winter and summer. They could still be seen in a very rotted condition when the tree was inspected in the following July. As it is known that bines from wilted hop plants will readily infect healthy hops when dug into the soil it is probable that the disease had been transmitted to the plum tree in a similar way.

Summary.—*Verticillium albo-atrum* Reinke and Berth. was isolated from a wilted Victoria plum tree which had apparently been infected from wilted hop bines placed around the base of the tree eleven months previously.

References.

Czarnecki, H. (1923). "Studies on the so-called black heart disease of the apricot." *Phytopathology*, **13**, 216-24.

Dufrenoy, J., and Dufrenoy, M. L. (1927). "Hadromycoses." *Ann. Epiphyt.*, **13**, 195-212.

Keyworth, W. G. (1942). "Verticillium Wilt of the Hop (*Humulus Lupulus*)." *Ann. appl. Biol.*, **29**, 346-57

Rudolph, B. A. (1926). "Verticillium Wilt of Tomatoes in California." *Phytopathology*, **16**, 234.

CHERRY SCAB (*FUSICLADIUM CERASI* (RABENH.) SACC.) IN KENT IN 1943

By M. H. MOORE

On 21st July, 1943, when Morello cherries were being picked at East Malling Research Station, the writer's attention was drawn* to the spotty skin of numerous fruits, representing in all a high proportion of the total heavy crop. The spots were small (mostly up to 2 mm. in diameter), circular, olive-green, and scattered over the surface of the fruits like the dried deposit of some unfamiliar spray-fluid. The resemblance ended there, for these spots were fairly regular in size and outline, and were velvety in texture like those of Apple Scab or Pear Scab. Numerous spores (conidia)† were readily liberated in water from the spots, and were found to conform to those of the Cherry Scab fungus, *Fusicladium Cerasi* (Rabenh.) Sacc.

As no previous records of this disease at this Station can be traced, the source of this sudden and severe outbreak is problematic.‡ A thorough search of bud-scales and young shoots was made, but no trace of the fungus was discovered. Even on the young leaves the disease was extremely hard to find, a long search revealing only some half-dozen leaves bearing minute spots that could very easily have been overlooked. These leaves were subsequently kept out of doors all the winter,

* By Miss E. C. Thompson who was recording the crop.

† Mean size (100 spores) 17·5 × 5·0 μ, 54 per cent. 17-18 μ long, 69 per cent. 5 μ broad, range 9-22 μ × 4-6 μ twelve spores one-septate, the rest non-septate. They were therefore much smaller than those (mean size 30 × 8 μ) of the Apple Scab fungus, *F. dendriticum*, and were also of a different shape, most of them being narrowly ellipsoid, rounded at the distal end and slightly wedge-shaped at the other. Some showed a very slight tendency towards the slipper shape of *F. dendriticum* with its central constriction in outline, but this was not characteristic. Their olive-green colour was very similar to that of Apple Scab conidia.

‡ Slight Scab was observed on Kentish Red fruits at this Station by Miss M. Bennett on 11th July, 1944, since the preparation of this paper for the press.

but the perfect stage of the fungus, *Venturia Cerasi* Aderh.,* was not found, so the source of the infection remains obscure.

Another feature of this outbreak was its prominence at the second picking. No comment had been made on the condition of the fruits at a first picking-over on 12th and 13th July for the earliest ripening ones, so it can be assumed that the spots were then absent or at least not numerous or conspicuous. Certainly at the second picking (21st July) it would have been impossible to overlook them.

Near the Morello plantation concerned there are two other plots of cherries, chiefly of sweet varieties but with some Dukes (or "hybrids") and some acid ones other than Morello. By 21st July the fruit from most of the sweet varieties had been picked and marketed, and those that remained showed little evidence of Scab. The disease was, however, found on a few fruits of the sweet variety Small Black Mazzard and of the Duke variety "Belle de Chatenay".† Of the acid cherries other than Morello, the varieties Carnation, Coe's Late Carnation, and Kentish Red yielded many scabbed fruits. It therefore seems reasonably certain that nearly all the sweet cherries escaped infection, possibly because most of them ripened earlier than the acid ones, which were themselves apparently free at a slightly earlier stage. Severe spotting would certainly have been very conspicuous on at least the "white" varieties.

Fig. 1.
Cherry Scab on fruits of Morello.

No measurable rain fell at the Station from 19th June to 5th July inclusive. On 6th July there was 0·43 in. and during the next five days 0·30 in. This total and its distribution over a six-day period, together with an adequate source of infection, would be enough to start an epidemic of "wet-weather" diseases such as the various fruit-tree Scabs. But even if spores were distributed on 6th July, at the beginning of the rainy period, numerous readily visible infections could not be expected at the first picking on 12th and 13th July, since the minimum incubation period is about eight days. Heavy visible infection could, however, be anticipated by 21st July in those circumstances. The innumerable, "pepper-pot" infections, even in one 12 lb. basket of fruit, indicated how prolific was the source of infection, of which some idea can be gained from the illustration in Fig. 1. Many of the more severely affected fruits shrivelled on ripening and in normal times would have commanded only a low price. Others were tending to shrivel before they were fully ripe. The top of the figure shows infection on unripe fruits, and the lower rows show affected fruits in progressive stages of ripeness to fully ripe at the bottom.

Extensive records could not be taken since the fruits were already picked and due for transit to market. Two baskets were chosen at random, however, one from each end of the plot, and one

* Not yet recorded for Britain.
† Nomenclature uncertain.

hundred fruits were taken at random from each, and graded by inspection for intensity of infection as follows :—

	none.	slight.	moderate.	severe.
East end of plot ..	12	26	19	43
West end of plot ..	14	49	21	16

These data confirm a general impression that trees were more heavily infected at the East (lower) end of the plot than at the West, which is much more exposed to wind and therefore tends to be drier.

At the Ministry of Agriculture's Plant Pathology Laboratory, Harpenden, the fungus has been reported on cherry only four times during the twenty-five year period covered by the Ministry's survey of plant diseases in England and Wales.* Traces were seen on market supplies about 1920. The disease led to severe premature fruit-drop in one place in Cheshire in 1930, and it was seen on Morello in Sussex in 1931,† and in East Anglia in 1938. Salmon and Ware (*Rep. S-E. agric. Coll., Wye*, No. **29**, Jan., 1932, p. 17) stated that the disease was sent in on Morello Cherry fruits from near Worthing, Sussex, on 14th July, 1931.† The related fungus on plum and peach has been recorded occasionally as *F. Cerasi* or *Cladosporium carpophilum*, but the view of Bensaude and Keitt (*Phytopath.*, **18**, 1928, 313-29), who regarded the species on plum, peach, and apricot (*Fusicladium carpophilum* (Thüm.) Oudem. (syn. *Cladosporium carpophilum* Thüm.)) as distinct from that on cherry, now finds general acceptance. Aderhold (*Landw. Jahrb.*, **29**, 1900, 541-88) obtained the perithecial stage (*Venturia Cerasi* Aderh.) in pure culture.

Scab on cherries is evidently common in some European countries,‡ notably Germany, where spraying trials have been carried out, and Switzerland. In Britain, the disease is clearly not of sufficiently common occurrence to warrant routine control measures, though if a severe outbreak such as that described here were to be anticipated, the use of a protective copper fungicide might be advisable.

The writer is indebted to Mr. N. H. Grubb for his helpful interest in this problem.

Summary.—The occurrence of an outbreak of Cherry Scab (*Fusicladium Cerasi* (Rabenh.) Sacc.) on the ripe and ripening fruits of Morello Cherry at East Malling Research Station in 1943 is described. From available records it appears that the disease has only infrequently been observed in England.

NUT DROP—A DISEASE OF CULTIVATED HAZEL NUTS§

By H. WORMALD

About the middle of July, 1943, cobnuts that had dropped from the bushes were sent to East Malling Research Station from a fruit farm near Sevenoaks, Kent, with an enquiry as to the cause of the trouble. These nuts had fallen long before they were ripe and the consequent loss was apparently serious, for the grower wrote, "There is no doubt that this Brown Rot is my trouble here as from 50 to 95 per cent. of the nuts have been getting it in recent years and dropping off in July and August. My own opinion is that this spreads very fast at this time, and though at present only 20 or 25 per cent. of the nuts show signs of it, it is quite possible that more will get it, and within a few weeks we may find, as we have done other years, that our crop has more or less disappeared."

The nuts are usually produced in clusters of 2 to 4 and infection of one or more in the cluster causes the whole bunch to drop. The nuts actually affected showed discoloured and somewhat withered bracts (the cupule), and when these bracts were removed the shells were seen to be brown, the browning being usually most pronounced at the base. The kernels were discoloured, and within some of the nuts fungous mycelium was visible to the naked eye.

After sterilizing the surface of the shells, nuts were split open and small bits of kernel removed and placed on prune agar plates. Some of these gave rise to cultures resembling those of *Monilia fructigena* (*Sclerotinia fructigena*), the fungus that causes Brown Rot of fruit, particularly apples, pears and plums. The split nuts were placed in a moist chamber, and in a few days most of them produced fructifications of *Monilia fructigena* consisting of yellowish tufts bearing chains of lemon-shaped spores measuring 15-24 × 9-12μ (mostly about 20 × 10μ).

* The writer is indebted to Mr. W. C. Moore for this and the following information.

† These records are identical.

‡ See *Rev. appl. Myc.*, **4**, 355 (Germany) ; **6**, 337 (Austria) ; **8**, 653 (Germany) ; **11**, 475 (Bulgaria) ; **13**, 706 (Italy) ; **15**, 75 (Spain) and 588 (Switzerland) ; **16**, 728 (Belgium).

§ Reprinted from *The Gardeners' Chronicle*, **115**, 1944, 60-61.

In order to confirm that this fungus isolated from within the nuts was indeed the Brown Rot fungus of fruits, it was inoculated into apples and plums, in large dishes in the laboratory. Within six days the plums were affected over the whole of their surface and bore fructifications of *Monilia fructigena*. The apples, being larger, bore pustules of the fungus over about one-third of their surface

FIG. 1.
Cobnuts bearing fructifications of the Brown Rot Fungus (*Monilia fructigena*).

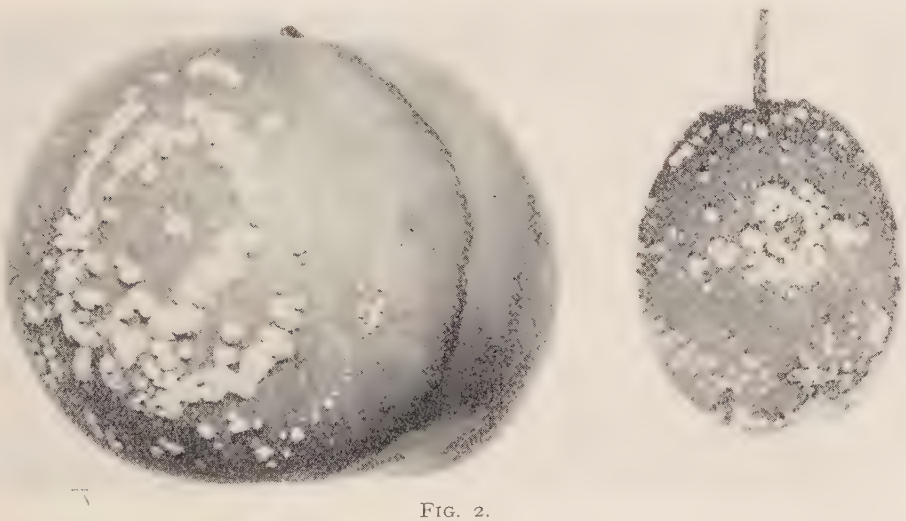


FIG. 2.
Apple and plum fruits six days after inoculation with *Monilia fructigena* isolated from a cobnut.

at this time, but in four more days most of them showed Brown Rot over their whole surface, and they bore Monilia pustules.

While these inoculation experiments were in progress other dropped nuts were sent in from the same farm, and some of these were bearing fructifications of *Monilia fructigena* when received, thus indicating that the fungus was fruiting on the nuts in the plantation.

From these observations we may conclude that this fungus associated with the premature dropping of cobnuts is the common Brown Rot fungus of fruit, and the well-known parasitic nature of the fungus suggests that it is actively concerned in this Nut Drop (to propose a common name for the disease) of cobnuts.

Other fungi were isolated from the same samples of fallen nuts and some of these were also able to cause a rot of apples and plums under laboratory conditions, so until comparative inoculations of nuts with these and *Monilia fructigena* have been made the primary cause of Nut Drop and the factors conducive to severe loss remain undecided.

Such a disease of cultivated varieties of hazel nuts appears to be unrecorded previously in Britain, but the association of *Monilia fructigena* with a similar Nut Drop has been observed on the Continent, and an illustrated description is to be found in Eriksson's *Fungous Diseases of Plants*, English translation (1930), p. 401. It was first described by Sorauer who found it in Proskau in 1887 (*Zeitschr. für Pflanzenkr.*, X, 1900, 152-154) ; by artificial inoculations he was able to infect hazel nuts, peaches and apricots with *M. fructigena* obtained from apple, and to infect apples and plums with the fungus from hazel nuts. The disease has since been seen in Sweden (1911-12) and in Austria (1922).

Cobnuts are almost invariably grown on fruit farms, and since apples, pears and plums are so readily attacked by *Monilia fructigena* such fruits would form sources of infection for the nuts unless measures were adopted to keep Brown Rot under control. On the other hand, nuts bearing *M. fructigena* will serve as sources of infection for apples, pears, plums, peaches and apricots ; this must also be considered, for Brown Rot of fruit in some years (e.g. 1943) is responsible for serious losses, and all possible sources of infection should be recognized, and eliminated as far as practicable.

As more information is required about this disease, its distribution and the fungi associated with it, growers who find their cobnuts falling while still unripe are asked to send particulars of the outbreak, together with specimens for examination, to East Malling Research Station.

Summary.—Nut Drop, a disease of cobnuts hitherto unrecorded for Britain is described. Of several fungi isolated from affected nuts, the one found most frequently was *Monilia fructigena* the common Brown Rot fungus of apples, pears and plums.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1943

By A. M. MASSEE

Introduction.—These brief notes which have appeared regularly each season in the Annual Report for the past twenty years are published with the object of reminding growers of the occurrence and habits of some of the insects which infest their fruits and hops during the year under review. During that time more than 170 species of insects and other animals have been mentioned at least once, while some of the more important pests have been referred to several times.

Since 1924 no less than 33 insects have been noted on fruit for the first time and recorded in these notes, and a few of them, indeed, are regarded to-day amongst our chief fruit pests, for example, the Fruit Tree Red Spider, the Strawberry Tarsonemid Mite and the Apple Fruit Rhynchites, to name only a few. The introduction of the woolly aphis parasite also has been recorded. A number of the species included in the notes are not regarded as economic insects, but their presence on fruit is unusual and worth placing on record.

The interest taken in these notes by growers and scientists alike is shown by the numerous enquiries and requests for reprints, particularly from the Entomological Departments of the Universities of North America.

The notes for 1943 appear below :—

1. Ghost Swift Moth (*Hepialus humuli* L.). When a consignment of Bramley's Seedling apples was removed from a gas store at Barming early in March, a number of fruits were noted to be infested by some kind of tunnelling insect. The tunnels in the sides of the fruits and penetrating to the cores, were of considerable size, their diameter measuring a quarter of an inch.

An examination showed that the damage was caused by caterpillars of the Ghost Swift Moth. They appeared to be quite normal in spite of their sojourn in the gas store since the autumn.

The caterpillar of the Ghost Swift normally feeds on the roots of various grasses, hop, herbaceous plants, strawberry, etc., thus its presence on Bramley apples in a gas store is rather unusual. Its colour is a dirty creamish white, with the head and second plate of thorax red-brown. It attains a length of two inches, and lives for two years in the caterpillar stage. The moth is on the wing in June and July.

2. Great Oak Beauty (*Boarmia roboraria* Schiff.). It is of interest to record the caterpillar of the Great Oak Beauty feeding on apple foliage on one of the plots at the Research Station early in March. In 1908 the late Professor Theobald reported receiving specimens of this species feeding on apple foliage from Ledbury, Worcestershire. It does not appear to have been noted again on apple

until the present record. The natural host plant of this insect is oak, and the caterpillar occurs on the tree from September until May, feeding in the autumn and again in the spring, and hibernating during the intervening period on the twigs. The caterpillar much resembles an oak twig. It is greyish-brown, with a pale line along each side, and a subdorsal line spotted with black and white ; it has lateral projections or humps on the sixth segment, and a projection below the seventh segment. The moth appears in June and July and it is regarded as a local species.

3. Strawberry Moth (*Peronea comariana* Zell.). The caterpillar of the strawberry Tortrix Moth was noted causing considerable damage to the foliage and fruits of Royal Sovereign and Huxley strawberry plants at Wisbech, Cambs., during the last week of May. Outbreaks of a less serious nature were reported also from Evesham, Worcs. By the end of May many of the caterpillars of the first brood were already fully grown, and some had actually turned into the chrysalis stage. The chrysalis is in a cocoon on the undersurfaces of the leaves. The chrysalis stage lasts three to four weeks and then the moths of the second generation emerge.

Although the outbreaks noted at Wisbech were serious, and the crops reduced in consequence, a high proportion of the larvae were parasitized by the minute four-winged chalcid wasp (*Copidosoma tortricia* Wtrst.). In some seasons this beneficial insect is known to effect economic control of the Strawberry Tortrix Moth, and the predominance of the parasite in 1943 seems hopeful in this respect.

Local growers state that some control of the tortrix moth can be obtained by the application of a 4 per cent. nicotine dust directly the attack is first noted.

Fortunately, at present this insect is of little or no economic importance in Kent, Sussex or Hampshire.

4. Codling Moth (*Cydia pomonella* L.). The Codling Moth, frequently referred to in these notes, has been one of the major apple pests of the season in Kent, and a few observations concerning this insect are worth recording.

Owing to the very early season the Codling moths were on the wing very much sooner than usual and adults were actually noted in the field at the end of April. The main hatch, however, did not take place until the second and third weeks of May. As might be expected the eggs were noted correspondingly earlier. Eggs were seen on the fruitlets of Cox's and Laxton's Superb during the first week of June, and by the 11th June eggs were prevalent on varieties subject to attack. The first Codling maggots were seen entering the fruitlets during the first week of June, and by the end of the second week hatching was general. It is considered that most of the maggots entered the fruitlets about two weeks earlier than last year.

As a result of the very early appearance of Codling Moth many growers were late in applying the arsenical spray, while others did not spray at all, and suffered considerably as a result.

With regard to the control of Codling Moth on apple it will be recalled that the recommendation is to spray with an arsenical wash, applied at the rate of 2 lbs. lead arsenate powder to 100 gallons of water at the end of June. The date of application must vary, however, according to seasonal conditions, and a correct timing of the spray can be made only as the result of field observations on the pest each season when egg laying is due to begin. In order to obtain a reasonable kill of Codling larvae by means of lead arsenate it is necessary to delay the application of the spray until some of the maggots have hatched and bored their way into the flesh of the fruits. This is considered advisable because the insect hatches out over a considerable period. In order to kill the maggots which have already bored into the fruitlets and are situated just under the surface it is advisable to add 8 ozs. of nicotine to the arsenical spray. Observations made during 1943 have confirmed the value of the addition of the nicotine, particularly when the spraying is behind schedule.

Fully grown Codling larvae began to spin their cocoons in July, and a few adult moths of the second generation were noted at the end of August. The second generation proved to be very limited and not regarded as causing economic loss.

Codling Moth larvae were also noted infesting pears in an orchard near Gillingham, but the attack was not very harmful.

5. Brown-tail Moth (*Nygmia phaeorrhoea* Don.). Although the Brown-tail Moth is regarded as a local species in Kent, it often occurs in some numbers along the coastal areas, and proved to be unusually common in the Isle of Sheppey in 1942.

The natural host plants of the caterpillar are elm, sloe, hawthorn, blackthorn and sea buckthorn, but in addition it feeds quite readily on the various kinds of fruit trees which are scattered about the coastal areas of Kent.

The caterpillar is blackish, with brown warts each bearing a brush of brown hairs, and it has a row of tufts of white scales on each side of the body from the fourth segment to near the tip. The central line is blackish, bordered on each side by a red line, and there is a vermilion round spot on segments nine and ten ; the head is dark brown to blackish.

The caterpillars hatch out in August and while still quite small go into hibernation in a common

nest. They become active again the following March and feed on the foliage until June, when they become fully fed and turn into the chrysalis state.

Several nests of these caterpillars were found by farm men engaged in tree pruning operations in the winter of 1942-43 in East Kent and they were sent to East Malling with a request for information concerning the habits of the insect.

Broadly speaking this insect is not common enough to cause much harm, but in the spring of 1943 it was sufficiently numerous in East Kent and in the Isle of Sheppey to cause considerable damage to apple and plum. It so happened that the caterpillars became active in the spring before the foliage had expanded ; as a result they fed on the buds, frequently denuding whole shoots and branches. The caterpillars retain their gregarious habit until ready for their final moult, when they disperse and form their chrysalids within a cocoon, attached to the leaves.

It should be noted that the caterpillars should be handled with considerable care, since at moulting time the fine hairs are liable to break off and cause considerable annoyance and irritation to the skin, frequently causing a rash on face and hands. In America the Brown-tail rash is very well known.

6. Dark Marbled Carpet (*Cidaria immanata* Hw.). The caterpillars of several species of moth feed on the cultivated strawberry, and it is of interest to add yet another to the list. The caterpillar of the Dark Marbled Carpet occurred in some numbers on strawberry foliage in widely separated parts of the country at the end of May. It was noted commonly feeding on strawberry foliage at East Malling, Evesham, and at Wisbech.

The caterpillar is a true looper or " stick " caterpillar. It is green with whitish tubercles, a line along back of darker green, and a fine white line along the sides with region around spiracles darker ; the thirteenth segment has two rosy coloured, pointed processes.

Its natural food plants include sallow, birch, bilberry, and wild strawberry, thus it is not unnatural that it should feed on cultivated strawberry from time to time.

The moth is a very variable species, having a wing expanse of 1½ inches. It is on the wing from June to September. The East Malling specimens emerged early in August.

7. Red Plum Maggot (*Cydia funebrana* Tr.). The occurrence of the Red Plum Maggot in plum orchards is very sporadic. In some seasons this insect may be plentiful, in others almost entirely absent. It was last referred to in these notes in 1935 when it caused considerable injury to several varieties of plum, rendering them quite unsuitable for canning. It is again causing considerable damage to the plum crops in the Maidstone and Malling districts of Kent, and it is also very prevalent in the West Midland fruit-growing areas.

Certain varieties of plum are much more subject to attack than others, and Victoria is included in the susceptible class. Warwickshire Drooper is also liable to attack, while Czar is very rarely infested, although it may be growing alongside badly attacked Victoria trees.

The red maggot of this small tortrix moth bores into the flesh of the fruit (in a manner similar to that of the Codling Moth larva) and hollows out the flesh around the stone. The partly chewed flesh and the frass left behind by the maggot gives the fruit a very unsightly appearance. A large number of fruits of Warwickshire Drooper were examined in September and it was found that the maggots did not bore into the centre of the fruits, as is their custom with other varieties, but confined their feeding to the flesh just under the skin.

The infestation starts about the middle of June, when the caterpillar hatches from an egg laid at the base of the fruit stalk. The majority of the maggots immediately burrow their way towards the stone. It should be noted that the fully grown maggot spends the winter in cracks and crevices in the stems of the trees, and also in the sack bands which prevent the support stakes from rubbing the bark. Thus orchard hygiene must be practised where this insect is prevalent.

8. Soldier Beetle (*Cantharis livida* L.). Regularly every season enquiries are made concerning the swarms of soldier beetles which are found on established strawberry plants in May and June.

This beetle is about half an inch long, light brown, with a red head and thorax, legs reddish, the hind pair banded with black. The antennae are grey, long and slender.

It is contained in a family consisting of about sixty species. They are mostly flower-loving species, and many of them swarm on the flower heads of the wild plants growing on the headlands of cultivated fields.

There is little doubt that the species found on strawberry in May and June is attracted there by the flowers, since as soon as the blossom period has finished the beetles fly off. The grub stages of many of the British soldier beetles are associated with the roots of grasses, and they live and undergo their immature stages in the soil.

The soldier beetles do not cause any harm to the strawberry plants, but in some seasons they are present in such large numbers that the growers naturally wonder if they are likely to cause any damage to the plants. Unusually large numbers of these soldier beetles were noted at Evesham and Wisbech in the last week of May. They were also prevalent in Kent in early June.

9. Strawberry Seed Beetle (*Ophonus pubescens* Ml.). The Ground Beetle or Strawberry Seed Beetle, as it is referred to by the strawberry grower, is contained in a group of beetles almost wholly beneficial, since both in the adult and grub stages they are predaceous, their food including many injurious insects.

Under certain conditions, however, the adult beetle feeds upon the ripening fruits of the strawberry frequently causing considerable damage. The chief injury is caused by the beetles removing the seeds from the ripening fruits. In addition the flesh is also eaten, the fruit cracks, and soon turns bad. Several closely allied ground beetles cause similar injury to the fruits, but the strawberry seed beetle must be regarded as the most important.

Although the injury caused by these beetles is more prevalent in the West Country than elsewhere, considerable damage is reported in Kent from time to time. The Mereworth, Borough Green and Ightham strawberry growing areas suffer each season from the attacks of these beetles. It is significant that most of the infested fields in these districts are adjacent to large wooded areas of country, and it is probable that the woods adjoining the strawberry fields are the natural habitat of the beetles. Very little can be done to prevent an attack, and the straw litter put on the ground to protect the ripening fruits from becoming blemished, provides an ideal hiding place for the beetles during the day time.

In affected areas a careful selection of the field should be made prior to planting, and sites liable to become infested by the beetles should be avoided.

10. Clay Coloured Weevil (*Otiorrhynchus singularis* L.). The Clay Coloured Weevil is a very familiar fruit pest which may cause considerable damage to newly grafted trees by gnawing the scions and destroying their buds, by defoliating young black currant bushes in the spring months, or by girdling the shoots of raspberry. In addition the grub stage of the weevil is responsible for destroying the tender roots of many of our cultivated fruit trees and bushes.

Enquiries received from the Malling district of Kent, Essex and Somerset show that the weevil is responsible also for another kind of injury. The adult weevils were noted feeding upon the developing apple fruit buds, just prior to the green cluster stage, and frequently completely destroying them. Considerable damage was noted in the affected orchard at Malling, and the damage continued until the buds were fully expanded.

The injury observed to the fruitlets in June is also of interest. The writer has noted a similar kind of damage in previous seasons but was unable to state the cause of the injury. The injury may be described as follows :—Little round, irregular areas, about $\frac{1}{8}$ in. diameter are eaten out of the fruit surface to a depth of $\frac{5}{16}$ in. Generally some eight or nine feeding punctures occur in a small area near the stalk. Sometimes the stalk is girdled or gnawed, but not invariably. This type of injury is severe enough to cause the fruit to rot, and it is not uncommon to find various lepidopterous larvae, such as the Clouded Drab and the Tortricids increasing the damage by feeding in the same area.

11. Apple Blossom Weevil (*Anthonomus pomorum* (L.) Curt.). The Apple Blossom Weevil must be considered a pest of primary importance in Kent and Essex, and it is also troublesome in other fruit growing areas.

Reliable control measures have yet to be discovered, but several means help to keep this pest in check, and one of these, practised extensively in Kent and Essex on bush and cordon apple trees, is the removal of the " capped blossoms " as soon as they show up sufficiently during the blossoming period. The collection of " capped blossoms " is a long and tedious business which cannot be carried out economically on large standard trees. In recent years the practice of removing " capped blossoms " from bush trees is becoming more general, and it is somewhat disturbing to learn that it is the custom of the grower to destroy the collected " capped blossoms " by burning them. Unfortunately it is not realized that a small percentage of the " capped blossoms " contain a parasite or natural enemy of the Apple Blossom Weevil, thus when the blossoms are destroyed the parasites are killed also.

Instead of burning the " capped blossoms " they should be spread out in tightly fitting wooden or cardboard boxes, covered with muslin or cheese cloth to prevent the weevils escaping when they hatch out of the blossoms. By the middle of June or so all the weevils will have emerged and in addition a number of parasites will have hatched out also. In order to collect the parasites the following procedure should be followed. When preparing the box to contain the " capped blossoms ", a round hole should be cut in the side of the box just large enough to enable the neck of a jam jar to be inserted securely into it. When in position the jam jar should stick out horizontally from the side of the box. When the parasites emerge they are attracted to the light, and fly into the jar from the darkened box. When several parasites have collected in the jar it can be removed, corked, and removed to the orchard where the parasites can be liberated in readiness to parasitize the next generation of Apple Blossom Weevil. It is not suggested the parasites will effect an economic control

of the Apple Blossom Weevil, but it is one, of several measures, which helps to check the spread of this serious pest.

12. Apple Sawfly (*Hoplocampa testudinea* Klug). The warm, sunny weather of April, 1943, brought the fruit trees into flower considerably earlier than is usual, and as might be expected, the Apple Sawfly also made an early appearance, thus the following observations upon this insect seem worth while recording.

Adult sawflies were first seen on the wing in both grass and cultivated orchards of Worcester Pearmain on 23rd April. This variety was in full bloom at the end of April and adult sawflies were very prevalent. By 5th May 80 per cent. of the petals had fallen and a number of sawflies were still active during sunny periods. Adults were noted again on 12th May in the Worcester orchard and two days later adults were seen in another plantation consisting of Cox and Worcester situated about half a mile away. A careful examination showed that the sawflies were still laying their eggs in the fruit trusses of Cox. This observation is of considerable importance, since it indicates that in some seasons egg-laying may continue after petal-fall. Petal-fall was complete in the orchard under discussion on 11th May and, as already stated, egg-laying was still going on on 14th May. It is considered that the peak of egg-laying occurred during the week ending 9th May, but that it continued for some time after that date.

The importance of knowing the period of oviposition is obvious since the timing of the applications of the post-blossom nicotine sprays must be adjusted accordingly. The first post-blossom nicotine spray should be applied when 80 per cent. of the petals have fallen, and it should be added to the routine lime-sulphur spray which goes on at this period. A second nicotine spray should follow some seven to ten days later in seasons when the sawfly lays some of its eggs after petal-fall.

13. Gooseberry Sawfly (*Nematus ribesii* Scop.). Although this is the first reference in these notes to the gooseberry sawfly, this insect is by no means uncommon in many parts of Kent, and frequently it causes serious injury by the caterpillar defoliating the bushes in a very few days, sometimes before the grower is aware of the presence of the pest. Several complaints and requests for information have been received from growers in different parts of Kent, and it is evident that the sawfly has been more common than usual during the past two seasons.

There may be three or four generations in one season (in 1943 there were four generations), the first appearing in the latter part of April and early May. The adult sawfly lays her eggs in a row on the under-surface of the leaf, usually near the midrib. Twenty or thirty eggs may be found on a single leaf. They are laid on a leaf low down, in the centre of the bush. The young caterpillars are gregarious but when about half grown they separate and feed on any part of the bush.

The grower is advised to keep a careful watch over his bushes in the spring so that an infestation, should it occur, can be taken in hand before the defoliation becomes serious. It must be borne in mind also, that if the first generation is controlled effectively, little damage will result from succeeding generations. The second generation occurs in June, the third in August, and the fourth in October.

This species of sawfly is also very partial to feeding upon red currant, and several bushes in gardens in the Malling district were defoliated during the summer.

Two other species of sawfly also feed on gooseberry, but they are uncommon in the South-East of England, and have not been observed in recent years in commercial plantations.

Fortunately the gooseberry sawfly is one of the simplest pests to control. It can be eradicated quite effectively by means of a lead arsenate, nicotine, derris or pyrethrum spray. Lead arsenate is probably the best wash to use against the first brood at the end of April. If, however, the fruit is formed before the attack is discovered, then a non-poisonous spray must be substituted for the arsenical spray. Dusts are also effective against the pest and their use may be preferred by growers instead of wet sprays.

14. Pear and Cherry Slugworm (*Caliroa limacina* Retz.). Although the Pear and Cherry Slugworm is not regarded as a major pest, the tendency of the slug-like larva to feed on the upper surface of the leaves, renders it very conspicuous, and in consequence it is readily detected by even the most casual observer. Its chief host plants are pear and cherry, but it is partial to several other plants in addition. The caterpillar was plentiful at East Malling on peach at the end of June, and on some wall trees of the varieties Peregrine and Hale's Early the damage was considerable.

In some seasons a second generation occurs in September. The sawfly was plentiful on several varieties of pear, and the larvae were still feeding during the second week of October at East Malling. They were not noted feeding on some cherries growing quite near, although this host is a favourite one.

Specimens of the larvae were brought to East Malling on 2nd September from a garden at Leybourne, Kent. They were feeding on quince and *Cydonia japonica* Pers. two unusual food plants.

The slugworm can be controlled effectively by means of a lead arsenate, derris or nicotine insecticide, applied in the form of a wet spray or a dust. If the first generation is controlled adequately by the treatment, the second brood should not be common enough to concern the grower.

15. Shy Bug (*Calocoris fulvomaculatus* De Geer). The Shy Bug or Hop Capsid Bug is not as widespread as it was twenty years ago, but it still occurs in sufficient numbers in many hop gardens to cause considerable damage to the growing bines. A number of hop gardens in the Rochester district are troubled by this insect year after year. It is usually confined to gardens where the pole-work method of growing hops is still practised, due no doubt to the fact that the insect lays its eggs in the poles, where they remain throughout the winter.

A severe infestation was noted at Cuxton where many of the bines had some thirty to forty immature bugs on each. The bugs feed on the bines, usually near the tips, causing the stems to " bleed ", and growth is checked. Not infrequently the growing point is injured by their feeding and forked growths result. The immature bugs are greenish-yellow to reddish-brown, and they start hatching in the middle of May. The fully winged adults are developed by the end of June and in July, and they are even more active than the agile immature stages. They deposit their eggs in hard wood of the hop poles at the end of July and in August.

This insect has many other hosts in addition to the hop, and it is found on several kinds of bush fruits, a favourite being the red currant. In gardens where control measures are necessary it is imperative to make regular inspections of the garden so that the hatching period of the bugs can be observed. When hatching has finished the garden should be dusted thoroughly with a 4 per cent. nicotine dust. One dusting should suffice provided it is timed correctly and applied on a suitable day. Nicotine dusts have been found superior to nicotine sprays.

16. Green Capsid Bug (*Lygus pabulinus* L.). The injury caused to many of our soft fruits by the Green Capsid, or Lygus, Bug is very well known to growers and need not be referred to here. In recent years, however, this insect has become much more prevalent on strawberry, particularly in the Wisbech district, where it is causing considerable injury to the plants.

An infestation noted on Huxley's Giant during the last week of May was very severe, and many of the plants were malformed. Immature green capsid bugs in the third or fourth stage of development, were still feeding on the foliage. No adults were observed. The Horticultural Superintendent of that district stated that the capsid bugs had been feeding on the plants since the beginning of May. He was also of the opinion that Huxley was very susceptible to attack, and that Royal Sovereign was also attacked, but to a lesser degree.

These plant sucking capsid bugs feed upon the tender leaves growing from the crowns of the plants. The injury consists of small brown areas on the upper surface of the foliage, usually along either side of the mid-rib. The feeding punctures turn black, the centres drop out, and holes are formed. These feeding punctures frequently malform the leaves considerably, making it difficult to recognize the variety.

Attacks by this capsid bug on cultivated strawberries are increasing in some districts ; in the Wisbech district there is some evidence that the bugs spend the whole of their life cycle on the cultivated strawberries, and that they spend the winter on the plants in the egg stage.

At present effective control measures have not been discovered. Nicotine dusts have not proved satisfactory, partly because of the failure to dust the plants effectively, on account of their low-growing and spreading habits. Gassing the plants with vaporized nicotine may prove an effective remedy if carried out when the bugs are very young.

17. Hop-Damson Aphid (*Phorodon humuli* Schr.). The prevalence of the Hop-Damson Aphid varied very considerably in different hop-growing districts of Kent during the summer months. Winged migrants from blackthorn were first noted on hops on 17th May ; hop lice were seen two days later in East Kent on Fuggle. During the latter part of May and in June large populations of aphids were built up in many gardens in East and West Kent, and the regular routine spraying operations were carried out as usual.

In the Weald of Kent, however, aphides were very scarce, and were entirely absent from many gardens. A number of growers have stated that it is the first season for many years that spraying operations have not been necessary throughout the whole season.

The scarcity of many species of aphides, including the Hop-Damson aphid, was a very notable feature in 1924, and was referred to in some detail in a Report by the late Professor Theobald.

The writer is unable to account for the prevalence of aphides in East and West Kent and their absence in the Weald. It is possible, however, that the abundance of ladybird beetles in hop gardens of the Weald in the spring months may be the explanation, since these predaceous beetles are very partial to the Hop-Damson aphid as food. It might be added that the very mild winter of 1942-43 proved very favourable to the adult ladybird beetles which hibernate in the cracks of the hop poles. In a very severe winter many of these insects perish. This cannot be the whole story, however, since ladybird beetles were also prevalent in the hop gardens in East Kent during the spring months. A correct interpretation of the above phenomenon would provide interesting reading.

18. Fruit Tree Red Spider (*Oligonychus ulmi* C. L. Koch). The Fruit Tree Red Spider is so

plentiful, and the damage so conspicuous in many apple and plum orchards of Kent and Essex that it is a general topic of conversation amongst fruitgrowers, and it is considered equally a serious pest to-day as was the apple capsid bug some fifteen years ago.

The hatching period on apple was very brief, and mature mites of the first generation were noted on the foliage by the first week of June. Observations made in a badly infested orchard at East Malling showed that most of the mites of the first generation matured about the same time, and that summer eggs of the second generation were being deposited on the foliage from 6th June onwards. Similar observations were made at Marden and Swanley. The first adults of the second generation were seen on apple on 13th June, but mites of this generation were not numerous until 21st June. Males proved to be very scarce, and it seems probable that they are more numerous later on in the season.

Observations made on plots at the Research Station receiving different spray treatments after petal-fall for various reasons, showed very clearly that those which received one or more lime-sulphur sprays were much less subject to red spider infestations later on in the season, than those plots on which the lime-sulphur was omitted.

It seems very likely also that the fruit tree red spider problem is closely bound up with such matters as the health and vigour of the tree, the amount of rainfall, and the type of soil formation. For example, in parts of Essex where the rainfall is light and the trees are growing in an unhealthy state on gravelly formations, the fruit tree red spider infestations are some of the most severe met with so far.

19. Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Bks.). In common with many kinds of injurious insects, the strawberry mite is more troublesome in some seasons than others. Doubtless it has been gradually building up its populations in the strawberry fields in different parts of Kent and elsewhere during the past three or four seasons, until it has reached a stage when it has become a serious pest. As mentioned in these notes in 1939, it was increasing in many strawberry fields at that period. To-day it is prevalent in most strawberry growing areas of Kent, and the Evesham and Wisbech districts.

Fortunately, the Royal Sovereign clone, Malling 40, has remained free from attack up to the present time. The infestation builds up during the course of the summer months (a dry season, such as that of 1943, being preferred), but frequently does not become conspicuous until well after the fruiting season. In Kent bad attacks were noted in August, but many more strawberry fields were suffering severely by the end of September. The mites cease to breed in the autumn, and newly developed leaves, which are not infested with mites, are formed around the crowns of the plants, thus during the latter part of the season the plants appear to stage a partial recovery.

It is significant that several bad infestations in Kent have been traced to the farm where the runners were obtained a year or so previously. The parent plants have since been ploughed in. Doubtless one of the chief means of distribution of the mite is on the runner plants. Growers are advised to inspect runner beds in the autumn to determine for themselves whether mite is present before purchasing new plants.

A reliable means of treating infested plants in established fields has yet to be discovered, but some control will be obtained by spraying with a 2 per cent. lime-sulphur spray about the third week of March, or more correctly when the mites are coming out of hibernation at the beginning of spring.

20. A New Red Spider on Prune (*Tetranychus* sp.). A consignment of red spiders infesting the foliage of Aylesbury Prune was sent to East Malling in October from an orchard at Ivinghoe near Aylesbury, Bucks. The red spiders were congregated in huge numbers beneath masses of webbing and underneath the bark. Both summer and winter forms of the mite were present ; the former were small yellow creatures about the same size as the common greenhouse red spider, while the latter were a brilliant red, and were adult females only. In common with other species of the family this species hibernates in the adult female state only, and is gregarious, living under a canopy of silken webbing.

The egg of the summer form is very similar to that of the common greenhouse species in size and shape, but its amber coloration at once distinguishes it.

It is not possible to determine the name of the species with certainty because of the impossibility of getting in touch with the continental authorities until after the end of hostilities. According to the works of Zacher and Hirst it is one of the true spinning mites, and it is included in the family *Tetranychidae*. The writer is of the opinion that the species is *Amphitetranychus viennensis* Zacher, 1920 (= *Tetranychus crataegi* Hirst, 1920) and the mite will be provisionally referred to that species. It has been recorded in this country previously by Hirst on hawthorn leaves in the outskirts of Salisbury, Wilts.*

* This species was sent to East Malling by Mr. G. L. Hey, Entomologist, the Murphy Chemical Co. Ltd., Wheathamstead, to whom the writer expresses his best thanks.

21. A New Tarsonemid Mite of Cereals (*Pediculopsis graminum* E. Reuter 1900). In June Mr. E. D. Wiggins, Assistant, Entomology Department, Seale-Hayne Agricultural College, Newton Abbot, Devon, called in at East Malling with some very interesting mite material he had collected in Devonshire, requesting that it might be identified if possible.

The mites were discovered in the first instance infesting oats in a field at Court Barton, Thurlestone, Devon, in July, 1941. A closer examination of the infested shoots revealed the egg masses of the mite in considerable numbers in the stems of the plants. A second infestation was noted at Waddeton, near Brixham, Devon, about a week later ; here again egg masses were present in large numbers. Investigations are in progress at Seale-Hayne in relation to the life-cycle of the mite, and to determine its economic importance, if any, in this country.

A detailed study of the mite shows that it is contained in the family *Tarsonemidae*, and that it belongs to the genus *Pediculopsis*. The name of the mite is *Pediculopsis graminum* E. Reuter, 1900. This is the first record of the occurrence of this mite in Great Britain. The only other species in the genus is *Pediculopsis ventricosus* Newport which occurs on warm-blooded animals, including human beings.

Pediculopsis graminum E. Reuter is well-known on the Continent of Europe and has been recorded from at least six countries. It causes a malformation of cereals and meadow grasses aptly described as " Silver Top ". It attacks oats, wheat, barley and rye and it has been recorded on about thirty species of meadow grasses. It is known also in the United States of America, where it has been reported from Illinois, Nebraska and Virginia. In America it is associated with the carnation bud-rot (*Sporotrichum Poae* Pk.). The rot is primarily due to a fungus, but the mite is an active agent in spreading the spores.

The mite is also known by the synonym of *Pediculoides graminum* E. Reuter.

The biology of the mite is extremely interesting and will be dealt with in good time. The writer is greatly indebted to Mr. E. D. Wiggins for bringing this mite to his notice, and for help in many other ways.

22. A Mite Injurious to the Cultivated Onion (*Petrobia lapidum* Hammer 1804). A species of *Petrobia* mite causing considerable injury to the growth of young onion plants was sent to East Malling from Evesham, Worcestershire. The mites feed on the growing points of the plants checking their growth ; eventually the plants wilt and become silvery in colour. The mite is closely allied to the Gooseberry Bryobia (*Bryobia praetiosa* Koch) and originally included in the same genus ; it was rightly split off, however, because of the characteristics of the cephalothorax. The *Petrobia* mite has a wide distribution in this country, and it is regarded as a common species living on and among rocks.

It is the only European species I am familiar with. Five species occur in America of which one is associated with onions, garlic and wheat.

Petrobia lapidum Hammer occurred in very great numbers in London in 1867, and assembled in vast numbers at Elmers End Station, where it was noted on fences, posts, and on pebbles and stones.

The egg is very characteristic and may be best described as resembling a miniature pork pie with a frill round the outer edge. The eggs are dead white and are laid in cracks on the undersides of stones lying on the ground.

It is curious that this mite should attack onions occasionally, but it is doubtful if it will become a serious pest, especially if the crop is not grown on the same ground two seasons in succession.

The writer is indebted to Mr. S. H. Bennett, Long Ashton Field Station, Evesham, Worcestershire, for sending this interesting mite to East Malling ; and to Dr. H. E. Ewing, of the United States Department of Agriculture, for his help in the determination of the species.

Summary.—Notes and observations are given on twenty-two species of insects and other animals observed in 1943.

FURTHER NOTES ON THE WOOLLY APHID PARASITE (*APHELINUS MALI* HALD.)

By A. M. MASSEE

Several attempts to establish the woolly aphid parasite were made in Kent from 1924 to 1938 (Massee, 1931). Parasites were liberated in woolly aphid infested orchards at East Malling in 1924, 1927, 1931, and again in 1933 (Greenslade, 1934), and at Chislehurst in March, 1928, and in February, 1929. Parasites were introduced into a suitable orchard at Paddock Wood in the spring of 1932 and in March, 1933 (Massee, 1933, 1935). A more recent attempt to establish the parasite was made in

1938 when several cages containing parasites were placed in a cordon apple plantation at Brenchley, Kent.

Observations were made in all these orchards for a number of seasons to watch the progress of the parasite, if any, in the various centres where it was liberated.

In the early days of this investigation the parasite undoubtedly made most progress in an orchard at Chislehurst where it was liberated in February, 1929. By November, 1930, the parasite had spread over three acres of Cox and other dessert varieties, and the black parasitized aphides were noted in every part of the orchard. There was no evidence, however, that the parasite established itself in that neighbourhood, and once it had parasitized all the woolly aphides in the orchard it disappeared, and has not been noted in the district since 1931. By 1939 woolly aphid colonies were establishing themselves again in the same orchard, but as already stated there was no evidence of the parasite.

In the orchards at East Malling, Paddock Wood and Brenchley it was found that the parasite persisted the winter following the season of liberation, but it was apparent that the parasite was not abundant enough to effect an economic control of the aphid. A possible explanation for the apparent failure of the parasite in these orchards may be due to the unfavourable weather conditions prevailing in the spring in this country, which prevented the parasite from building up large colonies until late in the season, and by this time the colonies of woolly aphides were well established. Thus it was concluded that the establishment and spread of the parasite did not seem sufficient to effect an economic control of the aphid.

Information received from the Chelmsford district of Essex in 1942 showed that the parasite had become established, and was rapidly colonizing itself over a wide area of the county where it had been liberated a few years earlier. The progress of the parasite was still more rapid in 1943. It was, therefore, decided to make a further survey in Kent of all the centres where the woolly aphid parasite had been introduced. The results of this survey proved of the utmost interest. In July it was noted that the parasite was abundant at Paddock Wood and Brenchley. It was also present at East Malling but not as common. By October, 1943, practically all the woolly aphid colonies in the orchards at Paddock Wood were parasitized, and the parasite was actually migrating to other infested orchards in the district. In other words the control exercised over the aphid was complete. The parasite was also abundant at Brenchley and it is estimated that one-half to two-thirds of the aphides were parasitized. The parasites were still active in the Brenchley orchard in November although their number was greatly diminished compared with the population in September. The infestation in this cordon orchard proved to be extremely severe, but it is considered that the parasite may effect an economic control next season provided it survives the winter, and starts breeding again early in 1944.

The parasite was originally liberated in two plantations in different parts of the parish of East Malling. The 1943 survey showed that the parasite persisted only at one of these centres. Here it proved to be in a very flourishing condition, checking the spread of the aphid very considerably. By the end of November a high percentage of the aphides were parasitized.

The parasite was not noted in the orchard at Chislehurst where it had been established some fourteen years previously.

It is difficult to explain how the parasite reappeared in such vast numbers in Kent in the summer and autumn of 1943, and it can only be assumed that it persisted in small numbers, but was not detected, in the various orchards where it was originally liberated, until the present day, multiplying very rapidly in 1943 when weather conditions proved congenial to the parasite. It is significant that the parasite was not noted in any of the orchards where it was originally liberated in the course of the surveys made in 1935 and 1936.

While it is generally agreed that the parasite can withstand very low temperatures (for example it thrives in some of the cooler parts of Russia) without apparent mortality, the damp, wet conditions of the English climate are not very suitable to its well-being (Stenton, 1925). With this aspect in view an attempt is being made to overwinter the parasite in both cold storage and dry storage conditions. For this purpose shoots colonized by parasitized woolly aphides were cut from infested trees in October, and housed for convenience in single layers in apple trays.

The infested shoots are being stored in a low temperature apple store, at a constant temperature of 37° F. and in dry storage in a boarded loft. A preliminary examination of the parasitized aphides early in February shows that the parasite has survived four months of dry storage without loss, and it now remains to be seen whether they will emerge in a normal manner in May.

Summary.—A brief account is given of the attempts to establish the woolly aphid parasite in Kent from 1924-38. It is shown that, while the parasite became fairly well established at one centre, it apparently failed to establish itself elsewhere. The spread of the parasite in 1943 in several of the centres where it was originally liberated is also discussed. The overwintering of the parasite in cold and dry storage is also mentioned.

References.

Greenslade, R. M. and Massee, A. M. (1934). "Some notes on the Woolly Aphis Parasite (*Aphelinus mali* Hald.)." *Rep. E. Malling Res. Sta. for* 1933, 225-7.

Massee, A. M. (1931). "Notes on Mites and Insect Pests for the Years 1928-30." *Rep. E. Malling Res. Sta. for* 1928-30 (*II. Supplementary*), 200.

——— (1933). "Notes on Insect Pests and Mites in 1932." *Rep. E. Malling Res. Sta. for* 1932, 115-16.

——— (1935). "Notes on Mite and Insect Pests for Year 1934." *Rep. E. Malling Res. Sta. for* 1934, 168.

Stenton, R. (1925). "Introduction of a Parasite of the Woolly Aphis." *J. Min. Agr.*, **32**, 343-9.

PLANT PROTECTIVE CHEMISTRY

SOME MODIFICATIONS OF PROCEDURE WHEN USING EGGS OF *Aphis pomi* (DE GEER) FOR THE BIOLOGICAL EVALUATION OF INSECT OVICIDES

By P. H. TUFT

The method employed at East Malling for the biological assay of ovicides, using *Aphis pomi* eggs as the test organism, has been described by Steer (1938). Experience gained from the use of this technique on a large scale over a period of several years has indicated a number of directions in which it could be improved.

The method as described by Steer consisted, in outline, of collecting infested material from the rootstock stool-beds during late November or early December and carrying it to a bird-proof cage near the laboratory to be heeled into the ground until required for the tests in January or February. The stocks were then taken to the laboratory and, after careful examination, 10 in. lengths bearing healthy eggs were cut from selected stocks. These shoots were then dipped, according to a standardized procedure, in a suitable preparation of the compound or mixture to be tested and then stored in pots of damp sand in an outdoor insectary. Towards the end of March, shortly before hatching was due to begin, a sample bearing about 300 eggs was cut from each of the shoots and placed in a glass tube. Over a period of about three weeks aphides hatched out from the viable eggs not affected by the treatment and died in the tube. When hatching was finished the eggs and dead aphides were counted in petri dishes over squared paper, the eggs having been removed from the twig, by heating at 70° C. for ten minutes in a 10 per cent. solution of potassium hydroxide.

The modifications that have been introduced concern the handling of the material up to the time of the tests, the solvent used to remove the eggs from the twig, and the procedure for counting the eggs and aphides.

It has been found that however carefully the bundles of stocks are carried from the stool-beds to the bird-proof cage, and later to the laboratory, some of the eggs are damaged. In order to localize and reduce this damage, the following procedure has been adopted. The stocks are packed in boxes and transported by means of small two-wheeled trailers. Damage is restricted to the ends of the stocks by arranging them in layers, with their roots projecting from one end of the box. The layers are separated from each other by two pieces of wood covered with corrugated cardboard and placed 24 inches apart.

The selection and cutting of shoots for the tests are carried out in the cage. The shoots, each 8 inches long, are cut from the protected portion of selected stocks which have been examined to ensure that they bear healthy eggs and are not over-populated. (Populations of over 400 eggs per inch tend to give anomalous results). They are then carried to the laboratory standing vertically in damp sand in troughs large enough to carry about 170 shoots ; no further handling is necessary until the shoots are dipped. In this way two people can prepare and dip as many as 340 shoots a day. The tests are carried out during January or February within as short a period as possible so that the eggs shall all be at approximately the same stage of development. Although the eggs of *Aphis pomi* are in a diapause condition throughout the winter and development is not resumed until some fourteen days before hatching (Baker and Turner, 1916), it is probable that the physiological activity of the embryo begins to alter some time before any morphological change can be seen.

The method of removing the eggs from the twig has been improved by the introduction of a new solvent. The use of potassium hydroxide as described by Steer (loc. cit.) requires very careful control of temperature and duration of treatment. Even so the twig tends to disintegrate before all the eggs

are removed, and those that remain may be hidden by debris. An attempt was made to avoid this difficulty by using different combinations of time, temperature, and concentration of alkali, but this was only partly successful. Alternative solvents were investigated, including a number of organic compounds of which chloroform, acetone, and benzene were fairly satisfactory, but difficulties arose because the detached eggs tended to adhere to the sides of the apparatus.

A series of trials was then carried out using solutions of sodium sulphide as solvent, since it was thought that the adhesive by which the eggs are attached to the twig might be of a protein nature. A 5 per cent. solution of sodium sulphide in 2 per cent. sodium hydroxide removed most of the eggs in five minutes at 100° C., leaving the twig almost undamaged. Although the twig tended to break down if the treatment lasted for more than ten minutes, it was still possible to count the eggs that remained attached. However, a year's trial of sodium sulphide solution as a routine solvent showed that its unpleasant smell and the irritant properties of its fumes outweighed its advantages and it was discarded in consequence. As the result of further trials an *alcoholic* solution of potassium hydroxide has been adopted as solvent. A 4 per cent. ethyl alcoholic solution is used and has proved highly satisfactory. At a temperature just below its boiling point, it removes the eggs rapidly, leaving the surface of the twig clean and firm ; the few eggs remaining attached are easily seen and there is no tendency for either eggs or twig to disintegrate even on prolonged treatment. The solution is free from objectionable odour and irritant fumes, but protection is necessary for the operator's fingers.

In addition to the introduction of the new solvent, a modified technique for counting the eggs and aphides has been developed. The five replicates representing each treatment are prepared at the same time, each twig being immersed in potash in a hard glass test tube bearing its number and heated for about three minutes at 70° C. in a water bath. The tube is shaken and the detached eggs collected on a 9 cm. filter paper by vacuum filtration in a Buchner funnel. The filter paper and the twig are then transferred to a glass plate on which is chalked the number of the treatment and the replicate. When all the replicates have been prepared in this way, the eggs are counted under a low power binocular microscope, using a hand tally counter. The dead aphides are shaken on to a filter paper moistened with 70 per cent. alcohol, and counted in a similar way.

In order to facilitate counting, the filter papers are marked out by means of a rubber stamp in 1 cm. squares, each square being slightly smaller than the field of the binocular microscope under which the eggs are counted.

The modified procedure and the use of the simple expedient described above, have resulted in a considerable saving of time. With only short breaks, two people can count five replicates every thirty minutes for periods up to five hours without undue fatigue.

Summary.—An account is given of the technique now used at East Malling for handling the experimental material for use in the biological assay of ovicides using *Aphis pomi* eggs as the test organism. The collection and transportation of the material to the laboratory, the use of alcoholic potash as a solvent for removing the eggs from the twig, and a simple device to facilitate the counting of the eggs are described.

References.

Baker, A. C. and Turner, W. F. (1916). "The Morphology and Biology of the Green Apple Aphis." *J. agric. Res.*, **15**, 961.

Steer, W. (1938). "Laboratory Methods for the Biological Testing of Insecticides." *J. Pomol.*, **15**, 338.

HOPS

PROPAGATION TRIALS WITH HOPS :

I. THE EFFECT OF TREATING CUTTINGS (STRAP-CUTS) WITH A GROWTH SUBSTANCE BEFORE PLANTING

By F. H. BEARD

Introduction.—At the present time there is need for the maximum production of healthy planting material. This can only be obtained by the intensive propagation from relatively small, carefully rogued parent areas by such means as layering. If full benefit is to be derived from the intensive propagation it is essential that the highest possible "take" is obtained from material planted in the nursery. In the case of ordinary cuttings (strap-cuts) we usually only obtain a take of about 75 per cent. at East Malling, though there is considerable seasonal and varietal variation. Under pot conditions in a greenhouse a "take" of from 90-100 per cent. is readily obtained. The success of

synthetic growth substances on the treatment of cuttings of many plants indicated that their effect on hop cuttings (strap-cuts) was worth investigation.

Experiment.—Five hundred cuttings of each of three varieties, Brewer's Gold, Bullion Hop, and Fuggle were placed in potato nets and soaked for twenty-two hours in a solution containing 20 parts per million of alpha-naphthalene acetic acid. This substance was used as it had given good results with soft-wood hop cuttings (Bailey, 1939) and is moderate in price. A similar quantity of untreated control cuttings was kept moist by bedding in damp soil. The cuttings were planted in randomized plots of 25. Subsequent treatment was that of our normal nursery routine of cultivations and spraying. The experiment was repeated in a second season. Planting was done on 5th March, 1942, and 4th March, 1943.

Effect on Shoot Growth.—In both years the treated cuttings were much slower in commencing growth above ground than the controls. Bullion Hop was the most forward and Fuggle the most backward. This condition was very noticeable in April, but later on the plots evened up and no differences were apparent to the eye.

Number and Weight of Rooted Plants.—In each season the plants were lifted in November and the number and weight of those fit for planting were recorded, and the number only of the very small useless plants. Lifting was done as carefully as possible ; however, since actual excavation was not possible, part of the root system was inevitably left behind in the ground. The proportion left behind was naturally the greater the larger the plant, small plants being lifted in their entirety. This bias should be kept in mind when considering the figures in the accompanying table which gives the mean percentage of good plants, the mean weight of 100 such plants and the mean percentage of useless plants. Statistical analysis of the data shows that in the first season treatment with the growth substance significantly increased the number of good plants in the case of Bullion Hop, but decreased

Number and Weight of Plants Produced.

	1941-42.				1942-43.			
	Good sets. %	Small sets. %	Av. Wt. of 100 good sets. lb.	Total sets. %	Good sets. %	Small sets. %	Av. Wt. of 100 good sets. lb.	Total sets. %
Brewer's Gold (treated)	82·8	9·6	14·3	92·4	66·8	14·4	10·8	81·2
,, (untreated)	76·0	17·6	16·1	93·6	80·0	9·6	12·8	89·6
Bullion Hop (treated) ..	78·0	8·0	12·6	86·0	74·7	10·4	11·2	85·1
,, (untreated)	68·8	16·0	14·3	84·8	78·0	12·8	12·0	90·8
Fuggle (treated) ..	68·8	12·8	15·6	81·6	78·4	10·0	12·0	88·4
,, (untreated) ..	84·8	6·4	15·0	93·2	92·4	3·6	15·2	96·0
Mean ..	76·5	11·7	14·7	88·6	78·4	10·1	12·3	88·5

the number with Fuggle. In the second season the growth substance significantly reduced the number with Brewer's Gold and Fuggle. The effect was inconclusive with Brewer's Gold in the first year and with Bullion in the second. The size of plant (as shown by weight) was reduced significantly by the growth substance in the case of Brewer's Gold and Bullion Hop in both seasons.

There was a definite correlation between the depressing effect on the initial shoot growth in the spring and the number of good plants produced.

Varietal Differences.—If only the control plots are considered they show that definite varietal differences occur. In the first season Fuggle had the highest " take " and Bullion Hop the lowest, whilst in the second year Brewer's Gold and Bullion were about equal with a distinctly lower take than Fuggle. There were also varietal differences in size of plant, particularly in the second season when Fuggle produced much larger plants than the other two varieties.

Discussion.—The results for the two seasons are in agreement, the differences being of degree only. The first season was more favourable for the treatment with the growth substance and gave significantly increased " take ", in the case of Bullion, a slight but not significant increase with Brewer's Gold and a definite decrease with Fuggle. In the second season conditions were evidently less favourable and the " take " was definitely lowered in Fuggle and Brewer's Gold whilst Bullion was less affected. Though in most trials with growth substances the treatment has given an increase

in the number of cuttings rooted, a few cases of the adverse effect have been recorded, notably in Ficus (Hubert and Beke, 1938), Rhododendron (Skinner, 1938) and Azalea (Yerkes, 1938). However, hop hardwood cuttings are very different from the ordinary type of cutting. They are swollen bases of the past season's bines and naturally root readily ; sometimes a small amount of root is already present when they are severed from the parent plant. The problem therefore appears to be one of obtaining a high percentage of saleable plants rather than difficulty in actual initial rooting. In the present trial the total number of plants lifted, both large and small, probably approximately corresponds to the number initially rooted, though it may be rather on the low side. It will be seen from the table that the total number of plants lifted is in several cases in the region of 90 per cent. or over. What is needed therefore is investigation into the conditions favourable to the initially rooted cuttings growing on into good plants.

A possible explanation of the differential varietal and seasonal response to treatment with alpha-naphthalene acetic acid is that it may in some way be associated with the physiological condition of the cuttings at the time of treatment. Fuggle is much earlier in season than the other two varieties, particularly so in starting growth in the spring. It grows strongly at first and gradually slackens growth as the summer proceeds, making little growth after early July. Brewer's Gold and Bullion start rather weakly but make very vigorous lateral growth late in the season. The cuttings were planted at the same period each season, but, whilst the winter 1941-42 was of exceptional severity with hard frosts persisting right up to the time the cuttings were taken, the winter 1942-43 was very mild. It is therefore almost certain that the cuttings in the second season would have been in a more advanced physiological condition. There is therefore some indication that the harmful effect of treatment with alpha-naphthalene acetic acid may be associated with a forward physiological condition of the cuttings.

Conclusion.—From the results of this trial the treating of hop cuttings, taken at the normal time, with alpha-naphthalene acetic acid is not to be recommended as it may cause a definite reduction in the number of plants produced. The results obtained from planting both treated and untreated cuttings taken at different times during the dormant season is worthy of further investigation when more is known of varietal differences. The trial has provided definite proof that varietal differences exist as to the ease of propagation and this aspect is now being investigated as a preliminary step to further trials of treatments designed to give a higher production of plants from the nursery.

Summary.—In two seasons' cuttings (strap-cuts) of three varieties of hop were treated with a solution of alpha-naphthalene acetic acid prior to planting. One variety was benefited by treatment in one season and not materially affected in the other. The second variety was adversely affected in both seasons and the third variety was adversely affected in one season. It is suggested that the differential varietal and seasonal response to the treatment may be due to the physiological condition (forwardness) of the cutting at the time of its removal from the parent plant. Apart from the effects of the treatment the varieties showed a natural variation in the number and size of the plants they produced.

Acknowledgement.—The writer is indebted to Mr. S. C. Pearce for assistance in planning the trial and for statistical examination of the data.

References.

Bailey, C. R. (1939). "Some preliminary experiments in the use of root initiating substances in hop propagation." *J. S.-E. Agric. Coll.*, **44**, 47-53, and *J. Inst. Brewing*, **45**, 611.

Hubert, B. and Beke, A. (1938). "Beworteling van stekken onder invloed van heteroauxine." *Meded. Landb. Hoogesh.*, **6**, 1-58.

Skinner, H. T. (1938). "Rooting response of azaleas and other ericaceous plants to auxin treatments." *Proc. Amer. Soc. hort. Sci.*, **35**, 830-8.

Yerkes, G. E. (1938). "Treat cuttings with indolebutyric acid." *Amer. Nurserym.* May.

Section IV

BULLETINS FOR FRUITGROWERS

THE PRODUCTION HISTORY OF THREE EXPERIMENTAL PEAR PLANTATIONS AT EAST MALLING, 1921-43

By T. N. HOBLYN

THE general considerations outlined in a recent paper describing the history of four apple plantations (Hoblyn, 1943) largely apply to pears also. All those plantations described here are experimental, the first forming part of the first quince rootstock trials, the second a mixed plantation containing rootstock pruning and manurial trials, and the third, a rather younger one, a pruning trial. Weather conditions, perhaps, play a larger part in the cropping of pears than of apples. However, apart from the direct effects of spring frost and cold winds, to which pears, being earlier flowering, are more likely to be subjected, it is not known exactly what combination of factors contributes to a "pear year". Since any of the pear trees at the Station were of bearing age, there have been six such seasons, 1934, 1936, 1939, 1940, 1942 and 1943, in which nearly all varieties cropped heavily. In other seasons, only a few varieties, such as Conference, Fertility and Beurré d'Amanlis, produced any substantial amount of fruit. The first pear plantings in the early nineteen-twenties seemed to indicate that pears might be expected to take longer than apples to yield their first crop. However, this was not confirmed by a planting made ten years later, the trees in which came into full bearing some four years sooner than in the older plantations. Certainly, the trees in the younger plantation were two-year-olds when they were planted, instead of maidens ; but on the whole the great difference seemed to indicate that the bearing age of pears might depend very largely on the occurrence of favourable seasons.

The cropping tables which follow are based on the individual tree yields as recorded in the field. From these yields 20 per cent. has been subtracted, this being considered a fair estimate of the wastage which occurs from various causes between picking and marketing.

1. Twenty-two-year-old Plantation of Conference Pears.

This was the first rootstock trial of pears to be planted at East Malling (Plot 36), the trees being planted as maidens in January, 1921, at twelve feet square. It forms part of the trials of pears on quince rootstocks, a number of other varieties being planted adjacent to it a year later. In it there were included trees on six varieties of quince collected at the Station. Three of these quince varieties were soon found to be more or less incompatible with all varieties of pear, and Conference was no exception. Most of the trees on the incompatible quinces died or were so stunted that they had to be grubbed by the end of the eighth year after planting ; but a few have lingered on to the present day, some apparently quite healthy, but the majority so dwarfed and unhealthy as to be merely " passengers " in the plantation. In this respect, however, the trees were typical of many commercial plantings of the same period. With Conference there has been no evidence of scion rooting on any rootstock. Table I shows the numbers of trees on the two groups of quinces and their subsequent history up to twenty-two years after planting.

TABLE I.

NUMBERS OF TREES OF CONFERENCE ON QUINCE ROOTSTOCKS PLANTED IN 1921 AND SURVIVING TO 1943.

	Number of trees planted, 1921.	Number alive and healthy, 1943.	Number alive but stunted, 1943.	Number died and replanted.
On Quince A, B and C (compatible).	78	75	3	0
On Quince D, F and G (incompatible).	48	5	7	36
Total ..	126	80	10	36

Out of 126 trees originally planted 90 have survived, but 10 of these are stunted and of little value. The 36 trees that died were replaced, mostly by trees of varying age from adjoining plantations on Quinces A, B and C. Five were on Quince F ; these were apparently healthy trees at the time but only one is growing normally to-day.

Cultural.—The plantation was interplanted from the start with gooseberries and these were maintained until 1936. Clean cultivation has been practised throughout, but in one or two seasons since the removal of the gooseberries, cover crops have been grown successfully and turned in. Mainly nitrogenous organic manures have been applied generously as far as possible. The trees have been leader tipped and long-spurred annually. Once the trees were in bearing the leader tipping might possibly have been harder with advantage, as the branches have become unduly long and slender in recent years, needing support whenever they carried a substantial crop. A trial of the effect of dehorning was carried out on part of the trees in 1938 and 1939, the branches being cut back into 4-5 year-old wood. The presence of the gooseberries in the plantation handicapped the efficient spraying of the pears. Lead arsenate had to be omitted from post-blossom washes, with the result that in several seasons caterpillar was not controlled efficiently. Apart from this, diseases and pests have not interfered with cropping. Conference is the most resistant of all pear varieties to frost damage at blossom time, but the pears which develop from frosted blossoms are largely seedless and malformed. Considerable crops of such pears were harvested in the three frost years, 1935, 1938 and 1941. In one season, 1940, some trees carrying a very heavy crop of pears suffered from drought and the fruit was very small.

Cropping.—The average crops obtained per acre and per tree are set out in Table II, which is divided into three parts (1) the first eight seasons (1921-28), (2) the ninth to the eighteenth season (1929-38), during which period only the trees originally planted on compatible rootstocks produced any substantial crops, (3) the nineteenth to the twenty-second season (1939-42), by which time the replanted trees had become established and were contributing very nearly as much per tree as those that had been there from the start. In each period the original trees and replants of all ages are given separately.

Table II.

Average Annual Production of twenty-two-year-old Plantation of Conference Pears on Quince at 12 ft. square in bushels (48 lb.) per acre and per tree.

	Number of trees per Acre.	1921-28. 1-8 years.		1929-38. 9 to 18 years.		1939-42. 19 to 22 years.	
		per Acre.	per Tree.	per Acre.	per Tree.	per Acre.	per Tree.
Original Trees	216	4·2	—	·150	**0·7**	304	**1·4**
Replants	86	0·1	—	15	**0·2**	116	**1·3**
Total	302	4·3	—	165	**0·5**	420	**1·4**

Full Plant of Original trees 272 bushels per acre 9 to 22 years.

As pointed out in the introduction, all these trees were slow to come into bearing compared with apples. The crops during the first eight seasons were negligible. In the ninth season and the four which followed it the trees originally on Quinces A, B and C averaged about half a bushel per tree every year, but it was not until the fourteenth season, 1934, that the first full crop of about one and a half bushels per tree was harvested. (For the purpose of this paper a bushel of pears is taken to weigh 48 lb.) During this second period, the original trees averaged 0·7 bushels per tree and only failed completely in one season, 1937, a year in which there was very little blossom. The replants produced about half a bushel in 1934 and 1936, but averaged under a quarter of a bushel for the period. The plantation as a whole gave 165 bushels to the acre.

During the last four-year period there were three " pear years ". In each of these years all trees averaged over one and a half bushels per tree, the average yield per acre for the period being 420 bushels. Despite the occurrence of one frost year (1941) this period probably gives an enhanced view of the average annual yield which may be expected from similar plantations on quince. The average crop of the trees originally planted on Quinces A, B and C from the ninth to the twenty-second year was just under a bushel per tree, or 272 bushels per acre at 12 foot square. This is probably a nearer estimate of the cropping which might be expected in commerce.

2. Twenty-year-old Plantation of Mixed Pears.

This plantation of pears (known as Plot 20) has, during the twenty years since the trees were planted, undergone rather many vicissitudes, even for a Research Station. Originally planted between half-standard plums and interplanted with black currants, the pears certainly did not get a very good start and cropping was probably delayed in consequence. Furthermore, the trees have been used for a variety of trials, apart from the original purpose for which they were planted. However, since plums and black currants were removed, the record of the majority of the pears may be used to give a picture of the cropping of mature trees of these varieties at the Research Station. Undoubtedly there are some " passengers ", but the criticism may legitimately be made of many commercial pear plantations established during the same period.

The two and a half acre plantation was first planted with half-standard plums at 15 ft. square in the winter 1920-21. The maiden pear trees were interplanted in the plum rows in January, 1923. Between the rows Baldwin black currants, planted in January, 1925, were grown for six seasons, being removed at the end of 1930. Two years later the plums were grubbed also. Thus, since 1932 the plantation has consisted of pears only, at 15 ft. square, with a wind break of cherry plums retained on the headlands.

The majority of the pears are of four varieties, Conference, Durondeau, Emile d'Heyst and Pitmaston Duchess. There are also smaller numbers of trees of Fertility, Hessle, Beurré d'Amanlis and Beurré Alexander Lucas. In addition gaps in the original plantings and certain rows originally of trees on incompatible quinces were filled with trees of several varieties. These, however, will not be included in the present review.

The trees were primarily planted for the purposes of rootstock and pruning experiments. Most of the trees were on quince rootstocks, the planting of Conference, for example, being a repetition of the Plot 36 quince rootstock trial; but with some varieties trees on quince and seedling pear rootstocks were also compared. The pruning experiments were similar to the original apple pruning trials at the Station, hard and light spur pruning being compared with " regulated " and " open centre " methods, while some of the trees were for a time unpruned to study varietal habit.

From 1935-40 the whole plantation was used for a simple manurial trial. The treatments were chiefly nitrogenous. All the trees received annual basal dressings of shoddy or dung and steamed bone flour; part received in addition heavy dressings of sulphate of ammonia, while to other plots sulphate of potash was given as well. Apart from a general improvement in the growth and cropping of the trees, no material differences were recorded in response to the differential manuring, there being evidently no actual deficiency of potash or nitrogen.

Here again some of the quince rootstocks proved incompatible with the varieties worked on them, consequently some trees died, while other trees became scion rooted and failed to crop for many years. Some headland trees were also removed to make way for new buildings and to allow more room where the plantation adjoined its neighbour. Of the original two and a half acres there are thus only about two acres of trees of which there is a record of the whole period, and these only will be considered here.

Apart from the pruning trial the pruning has depended upon the variety, methods of spurring and leader tipping being adapted to varietal habit. The very vigorous Pitmaston Duchess trees were not spur-pruned at all, but during the period have been severely dehorned at one time or another.

The spraying treatment has been that normal for pears and, apart from the variety Fertility which has suffered severely from Canker, pests and diseases have not seriously interfered with cropping.

TABLE III.

AVERAGE PRODUCTION OF TWENTY-YEAR-OLD PLANTATION OF MIXED PEARS AT 15 FOOT SQUARE PER TREE AND PER ACRE.

	1923-30. 1-8 years.		1931-42. 9-20 years.	
Number of Trees per Acre.	Per acre. Bushels.	Per Tree. Pounds.	Per Acre. Bushels.	Per tree. Bushels.
193	9·4	2·4	163	0·8

Cropping.—Considering the plantation first as a whole, no appreciable crop was harvested during the first six seasons from planting and the average crop for the first eight years was only 9½ bushels to the acre. From the seventh to the eleventh seasons (1929-33) crops of from 33-55 bushels per acre were harvested annually, but it was not until 1934, the twelfth season, that the first crop averaging a bushel to a tree was gathered. In this year the acreage yield was 203 bushels. During the next

eight years, crops of over 125 bushels were harvested in five seasons. In the other three, frosts reduced the crops, only Conference and to a lesser extent Durondeau and Hessle giving any substantial quantity of pears. The heaviest crop of 400 bushels per acre or 2 bushels per tree was obtained in 1939. The average crop from the ninth to the twentieth year was 163 bushels to the acre or just under a bushel to a tree.

Table IV sets out the average yield per tree for the different varieties. Since the number of trees of each varies considerably it is hardly worth comparing the acreage yields, but the main characteristics of each may be compared.

TABLE IV.

COMPARATIVE ANNUAL YIELDS OF DIFFERENT VARIETIES IN POUNDS PER TREE.

	No. of trees.	1923-30. 1-8 years.	1931-42. 9-20 years.
		lb.	lb.
Conference	96	2	53
Durondeau	69	1	32
Emile d'Heyst	81	3	46
Fertility	30	5	21*
Hessle	30	5½	53
B. Alexander Lucas ..	9	2	42
B. d'Amanlis	10	5	55
Pitmaston Duchess ..	40	0	21
Fondante de Thirriott ..	5	1	19

* Trees severely cankered.

The earliest varieties to come into cropping were Fertility, Hessle and Beurré d'Amanlis, each of which gave from 10 to 25 pounds of fruit per tree in the seventh and eighth seasons. Pitmaston Duchess was very slow to crop, but scion rooting of trees on quince and the fact that a proportion were on "free" pear rootstocks may have been largely responsible. The average performance of Emile d'Heyst would probably have been better had all the trees been on quince.

In the twelve seasons from 1931-42 Conference, Hessle, B. d'Amanlis and Emile d'Heyst gave the best average crops. Of these Conference was the most regular, while Hessle only failed in one season (1935). B. d'Amanlis and Emile d'Heyst were less regular but the former gave very heavy crops (up to 3½ bushels) in certain seasons. Fig. 1 compares the annual crops from 1931-42 of Conference and Beurré d'Amanlis both of which have about the same average yield for the period. Apart from its other qualities, the much greater regularity of Conference—even in "off" years, the yield was about three-quarters bushel per tree—justifies the confidence placed in this variety by growers. The poor record of Fertility was due to the very severe effects of Canker on this variety. Durondeau cropped regularly giving some fruit even in frost years, but the trees are small and in no season yielded more than two bushels per tree. B. Alexander Lucas was very irregular, giving no crop at all in inclement seasons. The crops of Pitmaston Duchess were very poor, failing completely in four out of the last eight seasons and giving only moderate crops in the others.

3. Thirteen-year-old Plantation of Mixed Pears on Quince.

The third plantation (known as Plot 27) is considerably younger than those already dealt with. It has had, however, several advantages due to the greater knowledge of pear-growing available when it was planted and the much greater uniformity of the material.

The plantation, which was designed as a pruning trial, covers about an acre, the trees being spaced at 12 ft. square. There are 32 trees each of nine varieties, three of which were not present in the plantation just described, and all were worked on Quince A rootstocks. Since none of the varieties is incompatible with this rootstock, there have been no losses from this cause, nor have any trees been permitted to form scion roots, with the possible exception of Doyenné du Comice.

The trees were planted in the spring of 1931 as two-year-olds, and from 1932-40 were interplanted with red currants.

This trial was a development of earlier pruning trials. The treatment of the laterals was adapted to the known habit of each particular variety and did not form part of the experiment, which was confined to differential tipping of leader growths and variations in the number of branches.

The land was formerly part of a hop garden and was in good heart when the trees were planted. The manuring has been fairly generous since. In a situation rather exposed to the north and east,

the plantation was divided into two parts during the blossoming seasons of 1938 and 1939, one of which was surrounded with a shelter of hop lewing, while the other was left exposed. No material results were observable from this treatment.

The undercrop of red currants did not interfere in any way with the spraying of the trees and all received normal treatment. In certain seasons, especially when the weather was cold and wet, a bacterial blossom wilt disease severely affected certain varieties, especially Catillac, and may have reduced cropping. Apart from this, diseases and pests were well controlled, even the variety Fertility being kept free of Canker.

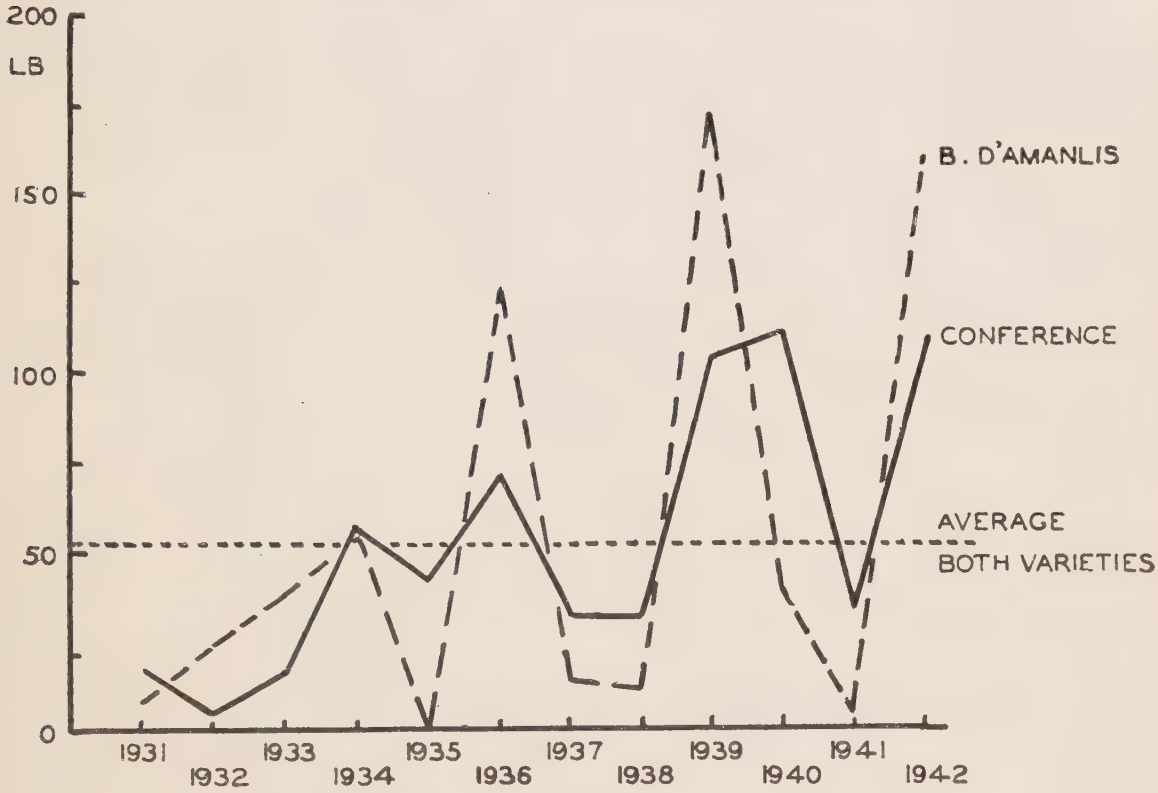


Fig. 1.
Annual cropping, in pounds per tree, of Conference and Beurré d'Amanlis.

In the last year of the period, 1943, part of the plantation where the soil is rather shallow evidently suffered from drought. This seems to indicate that it may not be possible to maintain the close plant for these varieties for very much longer.

Cropping.—The average annual crops for the first eight years and for the ninth to thirteenth years, for the whole plantation are summarized in Table V, giving the cropping of the hard and lightly tipped trees separately.

Table V.

Average Annual Crops per acre and per tree of a thirteen-year-old Plantation of Mixed Pears.

Method of Pruning Leaders.	Number of trees per Acre.	1931-38. 1-8 years.		1939-43. 9-13 years.	
		Per Acre. Bushels.	Per Tree. Pounds.	Per Acre. Bushels.	Per Tree. Bushels.
Lightly tipped ..	151	6	2	154	1·0
Hard Tipped ..	151	3	1	123	0·8
Total ..	302	9		277	

The cropping in the first eight years 1931-38 was very similar to that of the older plantations. Except for B. d'Amanlis in 1937, even the most lightly pruned trees did not give a bushel of fruit in any year. The only crop of any size, to which B. d'Amanlis and Fertility alone contributed substantially, was in that season.

In the five years since 1939 the cropping of this plantation has been very good for trees of this age. The average annual crop was 277 bushels per acre, or a little under a bushel per tree, for all varieties and methods of pruning. This is more than double the crop produced by either of the earlier plantings at the same age. Undoubtedly the absence of " passenger " trees has contributed to this result, as has also better spraying due to absence of an unsuitable undercrop. Nevertheless the occurrence of four seasons favourable for pears out of five during the period must have been largely responsible for this good result. The more lightly pruned trees have cropped more heavily during the period though on the whole the difference lessened as the trees grew older. As shown in Table VI, the lightly tipped trees gave their first crop of a bushel from one to three years earlier than where they were tipped hard. While the light tipping was advantageous in these early years, there is now the same tendency for the branches to become overlong and slender as noted in the earlier Conference plantation and it may soon be necessary to dehorn these trees.

TABLE VI.

YEAR IN WHICH DIFFERENT VARIETIES GAVE FIRST CROP OF A BUSHEL OR MORE OF PEARS.

Year.	1939.	1940.	1941.	1942.	1943.
Lightly tipped ..	(9) B. d'Amanlis B. Hardy Conference Fertility	(10) Catillac Pitmaston Emile d'Heyst	(11)	(12) Durondeau	(13) Comice
Hard tipped	B. d'Amanlis Fertility	Catillac Emile d'Heyst		B. Hardy Pitmaston Conference	

Judging the bearing age by the ability to carry a bushel of fruit, the nine varieties are grouped in order of coming into bearing in Table VII, which also gives the average annual crop in pounds per tree of all trees irrespective of pruning for the five-year period 1939-43.

TABLE VII.

AVERAGE ANNUAL CROP IN POUNDS PER TREE FROM THE NINTH TO THE THIRTEENTH SEASON. VARIETIES GROUPED IN ORDER OF BEARING.

Group 1.	Crop lb.	Group 2.	Crop lb.	Group 3.	Crop lb.	Group 4.	Crop lb.
B. d'Amanlis	81	Catillac	57	B. Hardy	47	Doyenné du Comice	12
Fertility	63	Pitmaston	39	Durondeau	23		
Conference	49	Emile d'Heyst	25				

Little comment is needed on the varieties included in earlier trials, except to remark on the good cropping record of Fertility when kept free from Canker, and the better record of Pitmaston. Fertility was the only variety to bear an appreciable crop in the frost year 1941, when even Conference did very poorly in this rather exposed plantation. Catillac is evidently capable of bearing heavy crops, averaging two and a half bushels a tree in 1942. Beurré Hardy is slow to come into cropping, while Doyenné du Comice only bore its first real crop of just under a bushel of fruit per tree in the thirteenth season.

4. Dr. Jules Guyot.

The varieties in the plantations above include most of those regularly grown in commerce during the last twenty years. Two more which are now often recommended for planting, Williams' Bon Chrétien and Laxton's Superb have not been grown here in sufficient numbers over a long enough period to give much idea of their cropping. One other variety very frequently grown commercially,

Dr. Jules Guyot, has been included in several trials though not in the plantations already described. This variety is more or less incompatible with all varieties of quince ; most of the surviving trees on quince rootstocks soon became scion rooted and cropped very poorly, only averaging about half a bushel per tree from the ninth to twenty-third years. A later planting of half-standard trees on clonal pear rootstock, planted in 1927 as three-year-olds, was also very slow to bear. These trees gave a first crop of about half a bushel in the tenth season from planting, but had no further substantial crop until the fourteenth season, 1940, in which they produced rather under two bushels per tree. This crop was repeated in 1942 after an " off " year due to frost, but the trees have not been in cropping long enough to give a reliable figure for the average annual yield.

Discussion.—It is a tradition in the fruitgrowing world that pears are slow to crop ; indeed it is often said that " he who plants pears plants for his heirs ". The first plantations of pears at East Malling seemed very generally to bear out this maxim, as it was not before the twelfth season that they averaged a bushel of fruit to a tree. The record of a later planting, however, shows that this is not invariably so, since this plantation, which included nine varieties, averaged a bushel per tree in the ninth season and maintained this average in three out of the four subsequent years.

It seems probable that the main reason for this difference was the weather conditions at blossoming time. Pears being early blossoming are more liable to spring frosts than apples and it seems that the first essential for a " pear year " is the absence of severe frosts and cold winds, when the trees are in bloom. Exactly what other conditions are needed is not clear, but it is evident that there is some factor or group of factors still to be discovered, which does not necessarily include the absence of a crop in the previous season, that must also play a large part.

Apart from these considerations there are large differences in the precocity of different varieties, some, such as B. d'Amanlis, Fertility and Conference, regularly coming into bearing early, while others such as Doyenné du Comice and Pitmaston Duchess are invariably slow.

Most of the trees in these trials have been worked on quince rootstocks, and cropping is not too long delayed, provided the varieties are compatible and scion rooting is prevented, but trees on pear rootstocks or allowed to form scion roots are again very slow.

Judicious pruning may make up to three years' difference in the year of cropping, and it would seem better to leader-tip naturally slow cropping varieties comparatively lightly in the early years if bearing is not to be unduly delayed.

Once they are in cropping the yields of these plantations average from 40 to 60 pounds a tree according to variety, apart from some of the shyer croppers such as Pitmaston Duchess and Doyenné du Comice. The average yield per acre of a mixed plant over a period of years seems likely to be from 180 to 250 bushels per acre depending upon the distance of planting.

Summary.—The cropping history of three experimental pear plantations, mostly on quince rootstocks, aged up to twenty-two years, is described. The year in which pears reach full bearing depends more upon seasonal conditions than with apples. Some varieties, even on quince, are much slower to come into bearing, while others on quince rootstocks, may bear their first crop of a bushel (48 lb.) of pears to a tree in about the eighth season from planting, like bush apples. Trees on pear rootstocks or scion rooted on quince are, however, always comparatively slow to bear. Some varieties, such as Conference, may be classed as regular bearers, giving from one to two bushels to a tree annually ; but others are much more irregular, giving heavy crops only in outstandingly good " pear years " and very little in those intervening. The average annual yield of a mature plantation of mixed varieties is from 180-250 bushels per acre, depending on the distance of planting.

Reference.

Hoblyn, T. N. (1943). " The Production of Fruit from Four Experimental Apple Plantations at East Malling, 1920-42." *Rep. E. Malling Res. Sta. for* 1942, **A26**, 96-102.

CORDON CULTURE OF APPLES

By H. B. S. MONTGOMERY

The chief aim in growing apples on cordon trees is to produce high quality dessert fruit. The use of so many trees to the acre (usually around 3,000) on relatively dwarfing rootstocks helps to obtain a useful crop at an early age, thus giving fairly quick return on the capital invested, but it is unlikely that the crops produced per acre when the trees are mature will be much heavier than those produced by mature bush trees. Most of the special operations involved in cordon growing are directed towards keeping the fruit easily accessible and at a convenient height from the ground so that the fruit can be kept under observation and the routine sprays can be most effectively applied.

Soil and Aspect.—Any soil suitable for bush trees of dessert fruit is suitable for cordons. It is preferable to have land towards the top of a gentle slope to the north or south as cordons being close to the ground are particularly susceptible to frost injury in the spring. On such a slope the rows can run up and down, thus impeding as little as possible the downhill flow of cold air on frosty nights in the spring, and at the same time run north and south, thus allowing the sun to shine equally on both sides of the rows. On other slopes the rows must run from side to side, thus increasing the frost hazard by possibly impeding the downhill flow of cold air, or run from east to west, exposing one side of each row to more sunlight than the other, both alternatives being rather unsatisfactory. The ground should be well cultivated before planting, and care should be taken to ensure that it is free from perennial weeds.

Rootstocks.—The very vigorous rootstocks, such as M. XII, M. XVI and " Crab " are unsuitable as they promote too much growth and unduly delay the carrying of full crops. With varieties such as Cox's Orange Pippin, that normally produce plenty of lateral shoots or spurs, M. IX is the best rootstock, producing heavy crops of high quality fruit with the smallest labour in pruning. Rootstocks M. I, M. II, M. IV and M. VII are also suitable, but being more vigorous, more pruning has to be done to keep the tree as a cordon. With varieties like Worcester, that fail to produce enough lateral shoots or spurs it is best not to use M. IX but to use a more vigorous rootstock such as M. I or M. II instead, as these stocks are specially suitable for Worcester. If M. VII and M. IV are available they are good second choices. If strong growth is produced it may be necessary to grass down the strips in the rows with a fine grass mixture after four years or so.

Variety.—Almost any variety of apple can be grown as a cordon provided the correct treatment is given, but certain varieties are seldom grown in this way, as they are unlikely to fetch high prices owing to their inherent poor appearance or flavour no matter how they are grown. The best varieties to grow as cordons are therefore choice dessert sorts, like Cox's Orange Pippin, Laxton's Superb, Lord Lambourne, Ellison's Orange, James Grieve, Fortune, Sunset and Laxton's Epicure, that can develop both good appearance and excellent flavour. Worcester Pearmain is sometimes grown as a pollinator for more desirable sorts, but would probably not be grown for the sake of its own fruits.

Supporting Wires.—A permanent system of wires to train the cordons on is required. Wooden supports are the cheapest but have a relatively short life and before using they should be treated, under pressure if possible, with creosote or other reliable wood preservative. More permanent supports can be provided by the use of iron or reinforced concrete posts set in concrete. As a rule the posts should be set at intervals of about 10 ft., and those at the ends of the rows should be stronger, if necessary being stayed so that they can take a considerable strain. The length of the posts depends on the height that it is planned to grow the cordons, but 7 ft. above ground level is a usual height. Such posts set in concrete would need 18 in. below the ground, or if set in soil, 3 ft. below ground.

Three wires are usual, the top wire being the strongest, gauge 10, as it eventually carries most of the weight, the lower ones being gauge 12 or 13. The top wire should be at about 7 ft., the middle one at 5 ft., and the lowest at 3 ft., above ground level. It is important to strain the wires tightly and for this purpose adjustable straining bolts at the end posts are useful. Stranded wire is an advantage as there is less tendency for the ties to slip on this wire than on plain wire.

The trees should not be tied directly to the wires; instead bamboo canes are first tied to the wires and the trees are trained along the canes. Although relatively short canes will reach from one wire to the next in the early years, while the trees are growing at an angle of 45°, when the trees are lowered to 30° much longer canes are needed or several short canes joined together. It is, therefore, advisable to start with canes 6 to 8 ft. long, that will still be long enough even when the trees are growing at a low angle.

The bamboos may be secured to the wires by wire or stout string, and they should be tied so that they lie between the wire and the tree. The trees should be tied to the bamboos by soft string, such as soft jute string. Wherever possible the trees should be on the lee side of the wire in relation to the prevailing wind, so that the wind blows the tree away from the wires and not on to them. This arrangement will be found to avoid chafing in high winds. The ties between tree and cane require examination and renewing annually, the best time for doing this being in the late winter. The ties should not be tied too tightly, especially in the early years when the increase in girth is proportionately most rapid, but should be left loose enough so that the season's growth will only just tighten the string by the end of the summer. Lack of care and attention to these ties, may result in their cutting into the bark of the tree with the attendant risk of canker.

Planting.—Maidens (one-year-old trees) are the best to plant. As it greatly facilitates the subsequent lowering of the trees they should be planted at an angle of 45°, and this has been found not to affect adversely the growth of the newly planted tree. The unions should be so arranged that the scion part, i.e. the shoot arising from the bud, is uppermost, as in this position the union is best able to withstand the strain involved in lowering the tree from time to time.

Although it is true that heavy crops in the early years can be obtained by planting closely, the increase in crop over that with a normal planting distance is hardly enough to cover the extra cost of the trees and labour of removing them at the end of six or seven years. On average fertile soils, the best planting distance in the rows appears to be 2 ft. for trees on M. IX, 2 ft. 6 in. for those on M. I, M. II, and M. VII, and 3 ft. for those on M. IV, with a minimum of 6 ft. between the rows. The distance between the rows is influenced by the width of the implements and machinery that will be used in the plantations.

Pollination.—This is of the utmost importance and the best arrangement is one row of the pollinating variety for every two rows of the main variety. This is better than putting pollinators at regular intervals in the rows of the main variety as it makes it easier to give the two varieties different manuring and pruning treatments should that become necessary. Reference should be made to leaflet No. 4 of the John Innes Institute (31 Mostyn Road, Merton, London, S.W.19) entitled " Fertility Rules in Fruit Planting ", for lists of varieties that suitably pollinate each other.

Pruning.—Two methods of pruning cordons are known to give good results and they both involve some summer pruning.

1. *The Modified Lorette System.*—In this system the pruning is done entirely during the growing season. In mid-July all the mature lateral shoots that grow out directly from the main stem are cut back to three leaves beyond the basal cluster of leaves, i.e. about the width of the pruner's hand (3 to 4 inches) and those from existing side shoots to one leaf beyond the basal cluster, i.e. about 1 to 2 inches, according to variety. A similar pruning is done in mid-September to any shoots that may have grown and matured since mid-July. If many immature shoots are pruned in this way by starting to prune too early, i.e. before mid-July, the tree becomes starved and weakened, showing this condition by producing yellowish leaves and undersized fruit.

The maturity of a shoot is judged by the colouring of its leaves and by the extent to which its base has become woody. At first the leaves are pale green and the shoot is soft so that it can be easily twisted round the finger, but as the shoot matures the green colour of the leaves darkens and the base becomes stiff and woody. On fairly vigorous cordons ripe shoots usually are nearly as thick as a pencil at the base and about a foot or more in length, but on less vigorous cordons, such as Cox on M. IX, many ripe shoots fail to reach these standards so that this guide is not a reliable index of maturity. The Modified Lorette System gives good results with all varieties, especially so with Laxton's Superb and " tip-bearers " like Worcester Pearmain.

2. *Partial Summer Pruning System.*—This method is almost fool-proof but it is not as suitable as the previous method for tip-bearing varieties. Half the pruning is done in the summer, usually in the early part of August, and the shortening of each shoot is completed in winter, towards the end of December. In early August every side shoot is cut back to 6 or 7 inches and in December these shoots are further pruned back to the width of the pruner's hand if they grow directly from the main stem, or to about 1 inch if they come from an existing side shoot. In this method there is no need to judge the maturity of each shoot before cutting it and the job is much more like trimming a hedge ; nevertheless some judgment is required in determining exactly when to begin the August pruning. If this is done too early in the summer, many newly formed buds will grow out to form weak unripe shoots by the autumn, eventually to be cut off in the December pruning. These " secondary " shoots, as they are called, rob the tree of valuable food materials and the growth of a great many of them is undesirable. If the pruning is done too late the main purpose of summer pruning is lost and the treatment becomes more like a winter pruning ; furthermore with varieties like Cox, especially in a dry season, the leaves on the lower half of the shoot may fall before pruning, so that, after pruning, a shoot devoid of leaves is left. As a guide the first week of August is the right time in a normal season in the south-east of England ; in a very dry season the pruning should be done about a week earlier, whereas it should be done a week or so later in a dull wet season.

It may be useful to use both methods of pruning in a cordon plantation in order to spread the labour over a longer period. If this is done the " tip-bearers " like Worcester should be pruned by the Modified Lorette System and spur-bearers like Cox by the Partial Summer Pruning System. Where there is doubt as to the ability of the pruners to judge the maturity of the shoots the latter method would be the safer one to use.

Treatment of Leaders.—As a general rule it is undesirable to prune the leader of a cordon tree unless it has been damaged by accident, pest or disease, as leader pruning delays cropping. There are, however, some varieties like Worcester Pearmain that normally produce side shoots at rather wide intervals thus furnishing the stem poorly and leaving considerable bare areas. A more even development of laterals can be encouraged in these varieties by removing about one-third of the leader each winter, and this is worth doing in private gardens where the trees may remain for many years and appearance and space effectively occupied are important considerations.

Training.—When the cordons have grown so that their tips reach the top wire, they should all

be loosened from the wires and lowered. The canes are first secured at the more oblique angle and the trees are re-tied to the canes. It is advisable to lower the canes as much as 15° each time to avoid the need arising more often than once every three or four years. When lowering, each cordon should be kept as nearly as possible straight from ground level to tip and roughly parallel to its neighbours.

Pest and Disease Control.—The normal routine sprays recommended for bush apple trees should suffice to control the usual pests and diseases, but cordons involve some special problems worth mentioning.

The pruning method removes many functioning leaves during the growing season and it is most important that the remaining leaves should not be damaged by harmful sprays. For this reason cordon growers usually avoid any spray that carries risk of damage, using a safer, if less effective spray, and relying on maintaining pest and disease control by the very thorough spraying that can be achieved on these trained trees. Thus " colloidal " or " dispersible " sulphur is frequently used post-blossom to control Scab, instead of lime-sulphur which is liable to cause damage under certain conditions.

The winter petroleum wash, indispensable for Red Spider control, though replaceable by thorough nicotine spraying before blossom for Capsid control, needs great care in application if severe damage is to be avoided. It has been found that damage often results when a second coat of spray falls on a tree already covered with a dry deposit of the wash. No risk is involved if the first deposit is still wet, for the excess spray will then run off. This double spraying is difficult to avoid if spraying is done in windy weather where the drift from a sprayed row may fall on neighbouring rows and dry before the sprayer comes to them. It is also bound to occur if very long rows are sprayed, one side at a time, because by the time the sprayer is doing the second side of the row the first spray may have already dried and the second spray inevitably overlaps the first. It is difficult to suggest ways of avoiding this trouble unless it can be arranged that both sides of each row are sprayed almost simultaneously, or that the rows are short enough for the two sides to be sprayed successively before the first side dries.

Aphis attacks, especially of the leading shoot, can be very troublesome even after thorough tar-oil washing in the winter. These attacks should be watched for and promptly stamped out by means of nicotine sprays.

Fruit Thinning.—The trees should not be allowed to set a crop near the leading shoot during the first season after planting, and after that the fruit should be thinned to get the required size. Too great thinning is wasteful, and the fruits that are left may grow too large for dessert purposes. Whenever possible the " king " fruit, i.e. the apple resulting from the top blossom of the cluster, should be removed as it often has an abnormal stalk and shape, and all other mis-shapen, damaged and diseased fruits should likewise be removed. With most varieties the fruits should be thinned to singles, leaving one fruit to each cluster, and with many varieties a further spacing out, to three or four inches between the fruits may be necessary. The thinning should be done immediately after the June drop. The operation of thinning should be done by picking the apple off its stalk, leaving the stalk attached to the spur. This method of thinning involves the least risk of knocking off the apple that is to be left on. With a little practice this operation can be done quickly and safely.

Acknowledgement.—The writer acknowledges with gratitude the assistance that he has received from Miss A. B. Beakbane, the results of whose experiments at East Malling Research Station on cordon growing have supplied the basis for this bulletin.

Summary.—A popular account of the cordon system of growing apples dealing especially with suitable rootstocks, planting distances, training and pruning.

DOUBLE-WORKING AND BRIDGING INCOMPATIBLE COMBINATIONS OF PEAR AND QUINCE

By R. J. GARNER

Many of the commonly grown pears make reliable trees when worked upon quince rootstocks but there are a few, amongst which is the variety Williams' Bon Chrétien, which are not always consistently satisfactory when united with quince by the ordinary methods of budding and grafting. Sometimes these varieties grow and crop normally for many years but usually there is considerable variation in the trees of a single planting. This may extend from the normal tree down to the tree that breaks clean off at the graft union a few years after planting. It is common to find plantations of Williams' Bon Chrétien on quince in which the trees vary in age from the twenty-year-old to the newly planted maiden. This condition is reached by annually replacing the trees which break off and, apparently, this procedure may well continue for so long as the same combination of scion and rootstock is

employed. It seems wise, therefore, to discount the somewhat small chances of obtaining good growth on single-worked trees and to take care to obtain really reliable trees at the outset.

The loss of trees by breakage at the union is due to a form of incompatibility in which the fibres of scion and stock fail to interlock. Though nutrients may pass across the junctions sufficiently to maintain adequate growth, there is little mechanical strength and any unusual stress separates the parts completely by a clean break, and so causes the death of the tree. The incompatibility at the union can be overcome by the use of an intermediate piece of another variety. This process is known as double-working and is done in the nursery by the tree raiser.

Double-working in the Nursery.—A variety known to unite well with quince is chosen for the intermediate. One that has been used on a large scale in many countries is Beurré Hardy. The variety Fertility has also been used with success, and Beurré d'Amanlis is quoted as an intermediate widely used in nurseries.

Trials at East Malling showed that perfectly good double-worked maidens of Williams' Bon Chrétien take no longer to produce than those single-worked, that is, two years from planting the rootstock. These double-worked trees were obtained by the ancient method of double-working in one operation in March, using the Whip-and-tongue graft (Fig. 1). The scion wood of both varieties was collected whilst dormant, and stored in the usual way. The scion wood of the intermediate variety Beurré Hardy, was cut into five-inch lengths in March and immediately grafted with a three-bud scion of Williams' Bon Chrétien, sealed and placed upright in a box of peat. Two or three days later these were grafted on the quince at three inches above ground level. More recent trials have shown that the first grafts may be made some weeks before the second, provided they are stored in a fairly moist and cool situation. When the operation was completed the length of the intermediate between the upper lip of the stock and the lower lip of the second scion was about two inches. Other methods of double-working were tried but that described proved the best. Of the 288 trees double-worked in one trial 281, or over 97 per cent., made saleable maiden trees.

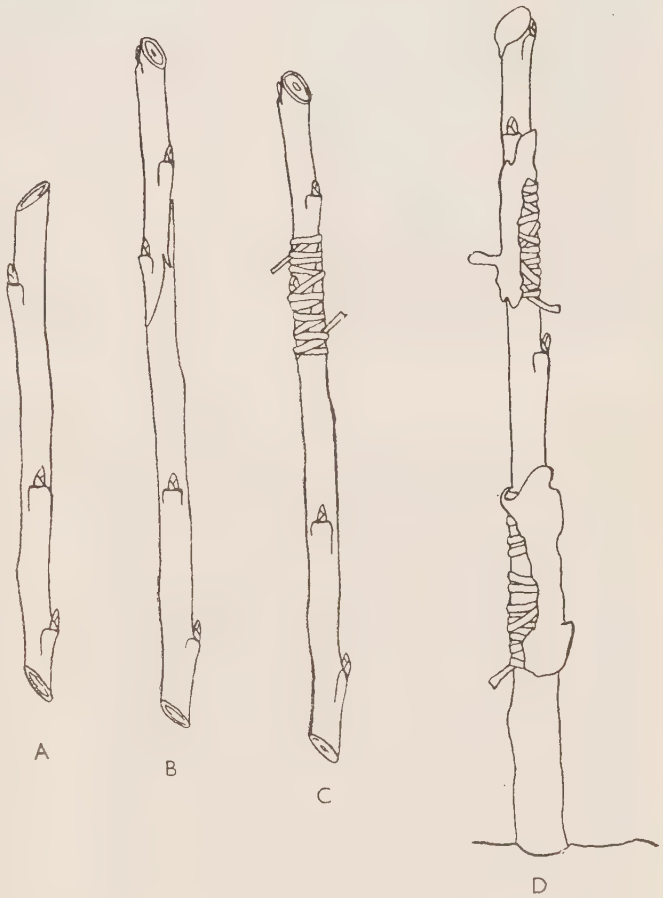


Fig. 1.

Double-working in the nursery.

(*a*) A five-inch length of intermediate (Beurré Hardy)
(*b*) A three-bud scion of Williams' Bon Chrétien grafted on to the intermediate of Beurré Hardy.
(*c*) Tied and ready for waxing before setting aside.
(*d*) The worked scion joined to the established quince root-stock in the nursery and sealed with grafting wax.

Bridging Incompatible Unions.—Double-working in the nursery ensures reliable unions but those growers already possessing young plantations of single-worked Williams' Bon Chrétien, and varieties which behave similarly, may wish to curtail further losses, and the following suggestions might be considered worth trying.

The first essential is to *stake thoroughly* so that the strain on the union is reduced. There are many methods of staking; slanting stakes are good but should be attached to the tree at a high level to lessen the purchase of the top. Vertical stakes, especially if attached at two places, are probably ideal, providing rubbing can be avoided.

Almost all trees planted in recent years have been set with their unions above ground level in order to prevent scion rooting. In these cases there is room to bridge the union by inserting an intermediate into the rootstock, but if the union is not clear of the ground the soil must be pulled away and not replaced by future cultivations, otherwise the intermediate bridge may root, usually putting the tree into a non-fruitful condition. Where the unions are deeply buried, bridging is not a practical proposition and in many cases the tree will have already scion-rooted.

Beurré Hardy and Fertility have been used for bridging single-worked trees of Williams' Bon Chrétien on Quince A. The scion wood is collected in the winter, and in March or April is inserted into the quince rootstock immediately below the union and into the scion variety a short distance above. The bridge should be as short as can be manipulated; this is usually about eight inches. Small trees two or three years old might receive one bridge but two bridges give more chance of success with larger trees. There are various ways of inserting the bridge, but a simple " side-cleft " appears

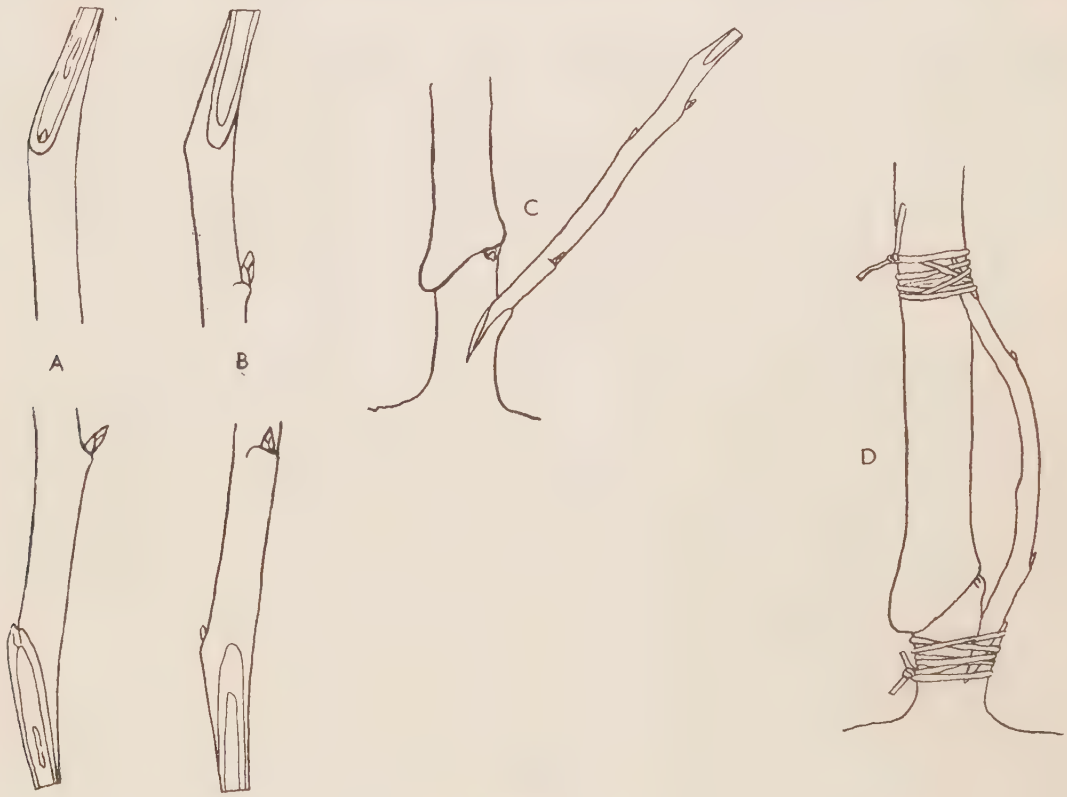


Fig. 2.

Bridging incompatible unions.

(*a*) The bridge showing cut surfaces to go towards the tree.
(*b*) Shallow cuts on the outside of the bridge to expose the cambium.
(*c*) The bridge inserted into the quince rootstock below the union.
(*d*) The bridge firmly tied and ready for sealing with grafting wax.

to be all that is required (Fig. 2). A shoot of the intermediate variety is cut into a comparatively long wedge by slicing away a bud and removing sufficient bark on the opposite side to expose the cambium. A cut is made downwards immediately below the union into which the base of the scion is inserted. This is now tied very firmly, with filis or tape, after which the upper end of the bridge is prepared and inserted similarly, but in the reverse direction, into the trunk above the union. Firm tying and thorough sealing of all cut surfaces is important, taking care that no holes are left for the entry of water between the bridge and the tree at the graft. Bridging the unions of large trees has not been tried but it seems likely that the bark graft, as used in frameworking, might be used in such cases with success.

Young growths from the bridges should be rubbed out as they appear and the tying material adjusted or removed before constriction occurs.

[*Photographs by H. B. S. Montgomery, East Malling Research Station.*

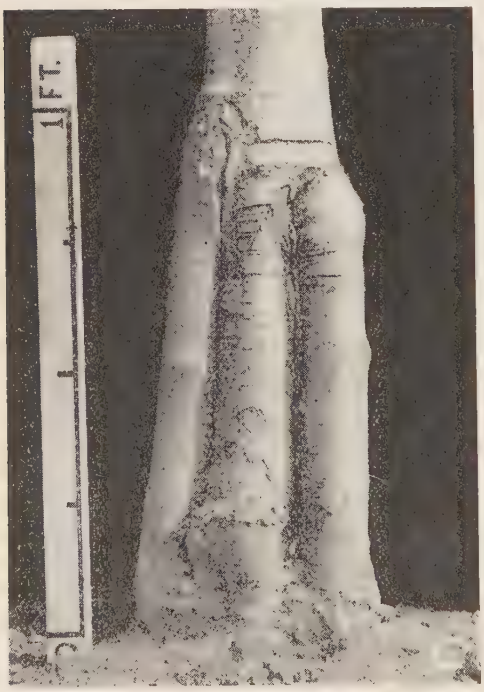
FIG. 3

Williams' Bon Chrétien on Quince A. Unions bridged with Fertility.

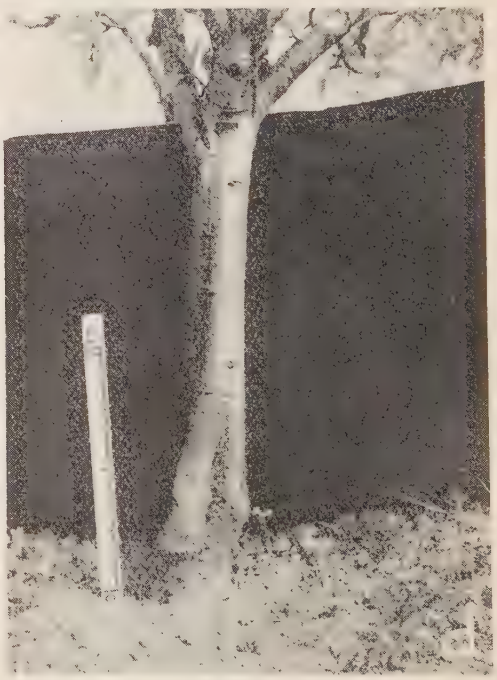
(*a*) Two-year-old trees receiving one bridge per tree.
(*b*) Two seasons' growth. Bridge on the left.
(*c*) Six seasons' growth. Bridge on the left.
(*d*) Fruiting tree six years after bridging. Bridge on the right.

[*Photograph by H. B. Montgomery, East Malling Research Station.*

[*Photograph by Eleanor C. Thompson, East Malling Research Station.*



[*Photograph by Eleanor C. Thompson, East Malling Research Station.*



[*Photograph by Eleanor C. Thompson, East Malling Research Station.*

FIG. 4.

Williams' Bon Chrétien on Quince A. Unions bridged, with Fertility, when five years old.

(*a*) Two seasons' growth.
(*b*) Six seasons' growth.
(*c*) Closer view of (*b*).
(*d*) Note rib which has developed above a bridge.

Successful bridges rapidly increase in size and soon begin to overtake the part bridged so that the single-worked tree becomes double-worked. The first bridged unions are now only six years old, and the performance of bridged trees cannot be definitely assessed, but it seems likely that successfully bridged trees will prove superior to those single-worked. At the same time it is obviously better to ensure good performance by the simple method of double-working in the nursery. Bridging should be regarded merely as making the best of a bad job.

The writer wishes to thank Mr. H. E. Bennett of Ditton Court and Mr. E. W. Gaskain of Selling for their collaboration and interest in the bridge grafting experiments and for permission to publish photographs of their trees.

Summary.—Double-working of pear trees in one operation, and the bridging of incompatible pear unions, are described with the aid of photographs and drawings.

ORCHARD SOIL MANAGEMENT, INCLUDING WATER CONSERVATION AND COVER CROPPING

By W. S. ROGERS

The Soil.—The soil consists of two main groups of components, mineral particles derived from the underlying rocks modified and often transported by water and wind, and organic substances, mostly the remains of plants which have grown in past times. In areas such as Essex and Kent, a very wide range of soils, from heavy clays to dry gravels and sands, exists, and it is readily apparent that these may need quite different treatments.

The Root Zone of Fruit Plants.—Excavations have shown that the zone occupied by the roots of fruit trees is very extensive. On loam (at Malling) roots of apple trees penetrated to the ragstone rock underlying the soil often at 5 ft., and in some cases as deep as 10 ft. On heavy clay (in Sussex), however, a water-table prevented root growth below about 3 ft., showing how lack of aeration due to water-logging can set a limit to the root zone. On light sand (at Wisley), the roots were relatively shallow, probably owing to the lack of nutrients in the lower layers ; but very extensive lateral spread was found. Thus on different soils any one of several factors, mechanical, physical, and nutritional can be the one which limits root growth.

The Part Played by Water.—Water is one of the most important factors in plant growth. It forms from two-thirds to four-fifths of the fresh weight of most plants, keeps the succulent plant cells turgid, and provides the largest constituent of the sap. All the nutrients absorbed by the roots from the soil have to be taken from a water solution. By far the largest amount of water, however, is evaporated from the leaves by the process called transpiration. The classical experiments of Briggs and Shantz and other workers have shown that, for each pound of dry matter added to the plant weight, between 300 and 600 pounds of water are used by transpiration. This water comes from the soil, which acts as a reservoir of rainfall (or any other water source such as irrigation). The water is held as a film between the soil particles and within the soil crumbs, and there seems little doubt that, especially in the dry eastern counties, it can be a limiting factor. We therefore need to conserve as much as possible for the use of our fruit plants ; and several methods are available.

(1) By making a large and deep soil block available to the roots—for instance, by breaking hard pans ; by drainage to allow deeper root penetration ; and, of course, by the choice of naturally deep soils.

(2) By avoiding severe plant competition—for instance, the keeping down of weeds in young plantations, and the very careful choosing of any cover crops that are used to suit the climatic conditions.

(3) By keeping a good humus supply in the soil, since this ensures better penetration of rain and greater water absorption. The water conservation effect of humus is greatest in sandy soils.

(4) By properly balanced manuring, both organic and inorganic, since much more growth is formed for the use of a given amount of water under good nutritional conditions than under poor ones.

(5) By avoiding drying winds—by the use of windbreaks (but remember that excessively vigorous windbreaks themselves can use a large quantity of water).

(6) By irrigation, where this is practicable. Space will not permit the full discussion of this practice here, but it has met with some success both on strawberry fields and in orchards at Malling.

Drainage.—It is worth emphasizing that fruit tree roots cannot withstand waterlogged conditions. Very often isolated wet patches in orchards can be cured by properly placing a single tile drain. Mole draining, with from one to three " moles " down the middle of each alley, has also been very

successful in some orchards on clay. In some clays, mole drains may not last very long, but their cost is so low that moling can be regarded as a regular cultural practice to be repeated every three or four years as required. This subject is well dealt with in a recent book by H. H. Nicholson (1942).

The Cultivation Programme.—Continuous clean cultivation has been the most usual practice in bush apple plantations, along with the copious use of dung and other organic wastes. Cultivation, of course, removes weeds, so reducing competition, and by stirring the soil increases aeration and stimulates bacterial action, so making available more nutrients ; but it must be realized that these nutrients are made available by bacterial rotting of the organic matter in the soil, so that this important soil constituent is definitely depleted by cultivation.

Organic Matter.—That organic matter is not absolutely essential for plant growth is proved by the fact that plants can be successfully grown in sand cultures and water cultures. Nevertheless, organic matter is most desirable in all ordinary soil culture, for it improves the physical, chemical and biological condition of the soil. In sand cultures fresh nutrients, correctly balanced, have to be added at short intervals—but organic matter acts as a kind of chemical sponge, a reservoir of nutrients more or less ready balanced. It is also a good regulator of the water supply, as stated above.

Mycorrhiza.—Another important aspect of the value of organic matter has recently been emphasized by Dr. M. C. Rayner (1943) who has shown that mycorrhiza, the association of plant roots and soil fungi, can play a very important part in enabling conifers to absorb nutrients from certain soils of poor fertility. These soil fungi require organic matter for their good development, and although it has yet to be shown whether they are important in fruit trees, there is little doubt that further study of this aspect of nutrition is needed.

Symptoms of Lack of Organic Matter.—Owing to the difficulty of obtaining supplies of farmyard manure and organic wastes, many orchards have had to do without organic manuring for some years. In some orchards under such conditions marked deterioration of the physical condition of the soil and, at the same time, unsatisfactory leaf conditions of the trees—suggesting deficient or unbalanced nutrition—have been observed. Various leaf scorches and excessive susceptibility to spray injury are among the symptoms which, though the matter is not yet definitely proved, appear to have increased as organic supplies have decreased. Conversely, renewal of the organic supplies has, in some cases, caused amelioration of the symptoms. This is not due to any mystical merit of organic substances, and similar cures have been affected by completely inorganic materials in certain cases, but organic matter apparently provides a safe and convenient method of ensuring a suitable nutrient supply.

" Ghost Flowers."—Another symptom about which more information is required is the appearance of " ghost flowers ", which are small, deformed, and pigmentless flowers noted particularly on apple trees. The spurs and sometimes whole branches on which these occur frequently die back, and as similar die-back symptoms have been found in several parts of Essex and Kent, there seems good reason for further study of this possible " deficiency symptom ".

The Maintenance of Organic Matter.—*Straw.*—Can a substitute for farmyard manure be found ? Will compost, straw or cover crops supply the answer ? Composts are excellent substitutes, but the labour of making them usually prevents their general use on a large scale. Straw, spread on the ground and ploughed in, seems worth serious consideration at present, as supplies are plentiful. We have seen good results following this practice, and some controlled experiments are now under way at East Malling. About 4 to 6 tons of dry straw per acre is spread on the ground, usually in autumn, and disced in when wetted by rain. An important part of the process is to add nitrogen, equivalent to $\frac{3}{4}$ cwt. sulphate of ammonia per ton of straw, to provide a nitrogen supply for the bacteria which rot down the straw. Addition of lime, except in soils already alkaline, also helps the rotting.

Cover Cropping.—Much more work has been done in America than in England on cover cropping in orchards. Experiments there have shown that while clean cultivation depleted the soil's organic matter, annual cover crops maintained or increased it, and permanent swards increased it still more. This was done under conditions of rainfall exceeding 40 in., however, or else under artificial irrigation. In England, rainfall may exceed 40 in. in the west, but is nearer 23 in. in the east. At East Malling water usage by a mature orchard normally exceeds the rainfall from about May to September, but rainfall exceeds the water usage for the rest of the year. It is clear, therefore, that any cover crop which is on the ground during the summer, and producing large amounts of growth at this time, may compete very severely for water as well as for other nutrients. Experiments at East Malling have shown that this is the case. Competition effects are most severe with the strongest growing permanent swards, and it appears that vigorous grasses like cocksfoot are undesirable for eastern conditions. Adequate nitrogenous manuring lessens the checking effect, and the inclusion of plenty of clover in the mixture sown is also an advantage, but a safer way of producing good amounts of organic matter, while at the same time avoiding severe competition, appears to be to use annual cover crops which are not actively growing during the dry season. A full report on the results of

cover crop treatments under trial at East Malling is now in preparation, but our present main conclusions can be summarized as follows.

For weak trees and dry climates, annual cover crops seem most suitable. Among the most promising are winter oats and tares mixed, sown at 84 lb. oats and 63 lb. tares per acre, or Crimson Clover (*Trifolium incarnatum*) at 24 lb. per acre, sown in late summer or early autumn, and turned in in May or June. The seedlings are liable to be damaged by tar-oil, and if winter washing is done over such crops it should be deferred until February. Early sown seedlings withstand winter conditions best.

If it is not desired to face the trouble and expense of sowing an annual cover crop, a cheap substitute can readily be obtained by leaving natural weeds to grow in the orchard from July onwards, and discing them in with a dressing of compensating nitrogen (about 1 to 2 cwt. of sulphate of ammonia per acre) in the following spring. Annual weeds make a cover crop of rather irregular and uncertain composition ; but, though experimental evidence in England is still lacking, they do seem a desirable minimum under present conditions.

For trees of medium vigour, short-term leys seem satisfactory, such as Perennial Rye-grass at 10 lb. plus Rough-stalked Meadow Grass 4 lb. and Broad Red Clover 12 lb. per acre, sown in the spring, and ploughed in two years later with a good dressing of nitrogen both during growth and at turning in. Another useful cover crop in this class is Lucerne, at about 20 lb. per acre, treated similarly, and not allowed to get too long.

For wetter conditions, and where it is desirable to check the trees, a more permanent sward can be established, such as Perennial Rye-grass at 20 lb., Rough-stalked Meadow Grass at 4 lb., Wild White Clover at 1 lb., and New Zealand White Clover at 1 lb. per acre. Such a sward should be kept short and well manured with nitrogen. In all cases the cut grass is allowed to lie and rot on the soil.

It should be emphasized that cover crops must not be regarded as a cure-all. They have certain definite effects, some good, such as improvement of fruit colour, lessening of premature fruit drop, curing of scorches, prevention of erosion, and provision of a good foot-hold in the orchard during the winter ; and some less desirable, such as checking of tree growth, by certain crops, and complication of the cultural programme by others ; but it does seem probable that some form of cover cropping, from autumn weeds as a minimum to semi-permanent grass as a maximum, will in future play a greater part in good orchard management practice.

It should be noted that the seed mixtures and manurial treatments will probably need modification to suit various localities, and it would be desirable to consult local horticultural officers before embarking on a cover cropping programme.

Summary.—Factors relating to orchard soil management including origin of soil, the root zone of fruit plants, water relationships, organic matter, and cultural programmes are briefly discussed. Measures are suggested for conserving or increasing the water supply, and the use of permanent and of mole drains in avoiding water-logging is described. The importance of organic matter is stressed, and methods for maintaining or increasing it by direct application of straw or by various forms of cover crops are described. It is important to suit the cover crop to the soil and climate.

References.

Nicholson, H. H. (1942). "The Principles of Field Drainage," pp. 165. Cambridge University Press, Cambridge, 12s. 6d.

Rayner, M. C. (1943). "The Use and Significance of Composts in Forestry." *Ann. appl. Biol.*, **30**, 397-9.

Rogers, W. S. (1941). "Practical Notes on Cover Cropping of Orchards." *Rep. E. Malling Res. Sta. for 1940*, 83-6.

THE PRODUCTION OF HEALTHY STRAWBERRY RUNNERS

(Methods recommended for Special Stock nurseries.)

By W. S. ROGERS and JOAN M. BUTTFIELD

Introduction.—In recent years virus diseases have provided a major problem in strawberry growing. Studies of these diseases by Harris (1933, 1937), Harris and King (1942), and King and Harris (1942), have shown the seriousness of the virus diseases Yellow-edge and Severe Crinkle , and that, once infected, a plant never recovers and the disease passes to all the runners that are formed. Massee (1935, 1941) has shown that these virus diseases are carried from diseased to healthy plants

by the strawberry aphid (*Capitophorus fragariae*). The strawberry aphid is difficult to control by ordinary methods, and since both diseased plants and strawberry aphides are common in the strawberry areas, it is evident that, for the raising of healthy plant material, special measures are necessary.

These measures will include starting with plants tested and found free from virus diseases, or, in cases where entirely virus-free plants cannot be found, as free as possible from severe forms of virus diseases. Such plants must then be raised in conditions which make reinfection unlikely, and which will also allow for the removal of any plants which may become infected. Such a system has been developed at East Malling Research Station, and has been used for raising runners in the Ministry of Agriculture's Nuclear Stocks Scheme, which is now being developed into a Special Stock Certification Scheme. The chief points of the system are : (1) Treating runner-raising as a specialized business entirely separate from fruit production. (2) Establishing runner nurseries well away from existing strawberry areas. (3) Raising runners in these nurseries by an " isolated block " system, which will be described later, to allow the systematic roguing and removal of all diseased plants and runners. Since the growers whose farms are best suited for runner production will thus often be those who are least familiar with strawberry growing, it is intended in this Bulletin to lay down in fair detail the procedure that has been found successful for healthy runner raising. Preliminary research results on which the method is based were described by Rogers, King and Massee (1939).

Varieties and Stocks.—First it must be realized that strawberry varieties do not all behave in the same way with regard to virus diseases. Some show symptoms fairly readily when infected, and these are classed as " virus sensitive ". Others, when infected, do not show symptoms readily or completely, and these are called " virus tolerant " ; still other varieties are intermediate between these extremes. From the practical point of view this means that virus-infected plants can be fairly efficiently removed on field inspection of " sensitive " varieties, but this is not possible with " tolerant " varieties. Therefore " tolerant " varieties must not be grown near " sensitive " ones, for the former would act as a source of infection for the latter. Examples of " sensitive " varieties are Royal Sovereign and Sir Joseph Paxton ; at the other extreme, markedly " tolerant " varieties are Huxley, Oberschlesien and Madame Lefebvre. Intermediate varieties are Tardive de Leopold and Western Queen, but as these cannot be relied upon to show virus disease symptoms at any given time, for runner raising purposes they should be classed with the " tolerants ". Even the " sensitive " varieties do not show symptoms clearly all the year round, and roguing must be done at the right periods as described later. In any given nursery, therefore, either " sensitives " or " tolerants " should be chosen for propagation and never both together. The variety chosen for raising will largely depend on the market which it is intended to serve ; for instance, the Wisbech growers at present demand mainly Huxley, while Devon, Cornwall and Somerset need Royal Sovereign ; in Kent both varieties are important. The most suitable stocks available are the tested clones raised under the Nuclear Stocks Scheme. These have been subjected to both pathological and pomological tests, and have given very satisfactory results. The clones at present (1944) approved as parent plants for Special Stock Nurseries are Royal Sovereign M40, Huxley M44, and Oberschlesien M42. Other stocks and varieties are still under test.

Locality.—The feature of greatest importance is distance from possible sources of infection, therefore localities away from the main strawberry growing areas should be chosen. Climate and soil are also important factors ; the heaviest soils should be avoided, and very light sands are not suitable, though soils of lighter type are fairly satisfactory in areas of high rainfall. Medium loams are the most suitable. Runner yields are greatly affected by drought, and the drier areas, such as the Eastern Counties, are less favourably situated in this respect. In the wettest areas of the West, however, heavy rainfall, though promoting high yields, may interfere seriously with runner lifting at the correct times. Land exposed to high winds is not suitable, but frost is not an important factor. Ideal conditions would probably be well watered river valleys in the middle of grassland country where no strawberries are grown, and some such sites have already proved most successful. It must be pointed out, however, that if runners are raised in localities too remote from the main purchasing areas, viz. Wisbech, Kent, Hampshire and Worcestershire, difficulties may arise in marketing, for rapid transport is most important for these leafy evergreen plants. Convenient access to a railway station is therefore important.

Cultural Methods.—*Choice of field.*—A field well isolated from other strawberries, especially old fruiting beds which are fairly certain to contain diseased plants, is essential. About one mile has been found fairly satisfactory, though even this is not a perfect safeguard. The field chosen should be free from, or wired against, rabbits, and have only a low wireworm population ; these points are important as either pest can ruin a runner bed very quickly. Experience has shown that it is desirable to avoid old meadowland and grass leys because of wireworm infestation. Good air circulation but not exposure to the roughest winds is desirable. The field should be in good heart and as free as possible from weeds, for weed control is one of the main problems in runner raising. Special Stock

runner beds must not, of course, immediately follow a previous strawberry crop, on account of the risk of survival of some plants of the old stock.

Preparation of Ground.—The strawberries should occupy a place in the rotation where the ground can be made available for planting in October. About 20 tons of farmyard manure or equivalent compound organic manure should be ploughed in before planting, and the land well firmed. Potatoes have proved a very satisfactory previous crop.

Marking.—For the isolated block system, the plants are normally spaced at 3 ft. square, giving 4,840 plants per acre (Fig. 1A). In areas of very strong growth the spacing is sometimes increased up to 4 ft. square, or 2,720 plants per acre. In areas of weak growth, or where there is reason to expect heavy plant losses from any cause, a maximum of six plants may be planted in a 3 ft. square (7,260 per acre) as shown in Fig. 1B. Within limits, the wider the plants, the greater the runner yield *per parent*, and the closer the plants, the greater the yield *per acre*. Various other spacing modifications have been tried, to suit different methods of tractor cultivation, but so far the 3 ft. square block has proved most generally satisfactory. In any case, a 3 ft. alley between blocks is the minimum for effective isolation of the runners.

For large areas the actual marking is conveniently done with a marker such as is used for cabbages ; or a drill or converted horse-hoe can be used. For small areas a marked line is quite satisfactory. It is, of course, important that the plants should be in line in both directions.

Nicotine dipping of runners.—To ensure that the bed starts free from strawberry aphid all runners should be dipped before planting in a solution of nicotine 1 oz., soft soap 1 lb., and water 12½ gallons. The plants can safely be immersed, roots and all. This precaution is worth while, even if the plants have been previously nicotine vaporized, for it is the one time when it is cheapest and easiest to get a good control of strawberry aphid.

Planting.—In most areas and on most soils autumn planting gives the best results, September to November being usual for eastern and southern England, and rather earlier in the west. The important factors are that the soil should be both warm and moist. Winter planting usually results in severe losses, and spring planting, though satisfactory in some areas, generally gives later runners and lower yields. In planting it is most important that the crown should be just at ground level ; if too deep it will probably be smothered and rot (or throw a number of weak crowns), if too shallow the plant may dry out. Bad planting adversely affects the performance of the runner bed for the whole of its life. After frosts the plants must be firmed, and in periods of alternate frost and thaw several firmings may be necessary to avoid losses.

Spring Operations —In early spring, February to March, the bed should be gapped up with comparable parent plants, of which it is desirable to lay in a small reserve in a sheltered situation. As soon as the plants are clearly visible the soil should be carefully hoed and a top dressing of meat and bone meal applied at 6 cwt. per acre.

Deblossoming.—All blossom trusses should be removed before the fruits set. Secondary trusses may be produced about a fortnight to three weeks later and these should also be removed. Deblossoming is important because it concentrates the strength of the plant on runner production, and also avoids the risk of seedlings arising in the runner bed. In Kent the plants are usually ready for deblossoming about the third week in May.

Mildew Control.—Towards the end of May or in early June, the bed should be dusted with flowers of sulphur as a precaution against mildew. This should be done before the mildew appears. A further application will probably be necessary in August. If a dusting machine is not available, shaking the dust through a sack of suitable mesh, held over the plants, is reasonably satisfactory. Mildew attacks make virus-roguing difficult, and also give a poor sample of runners ; so precautionary measures are very important.

Laying in of Runners.—As the runners develop from early June onwards, they are laid in, first from pairs of plants and finally into blocks of four plants as shown in Fig. 1A, to form isolated blocks, allowing cultivated alleyways between. Stones are usually placed on the first runners to hold them in position while rooting. It is important to lay all runners in their final position before rooting starts as otherwise they will be badly formed, with a poor root system at the side rather than a good one at the base. When laying is kept well ahead of runner growth much labour can be saved by using a small stick for whisking the runners into position ; but if rooting has already started, laying in can only be done by workers on their hands and knees. The bed will have to be gone over several times, especially after rainy periods. As the block becomes filled with runners towards the end of the season, later formed ones can be laid round the outer edges of the block in the alleyways. These can be left undisturbed at the autumn lifting and will be ready for sale in the spring. No limitation of runners has been found to be necessary or desirable (Rogers, King and Massee, 1939).

Cultivation and Hand Weeding.—Horse hoeing should be continued in the alleyways until the end of September. Weeds within the rows and blocks can be controlled to a great extent by hand hoeing

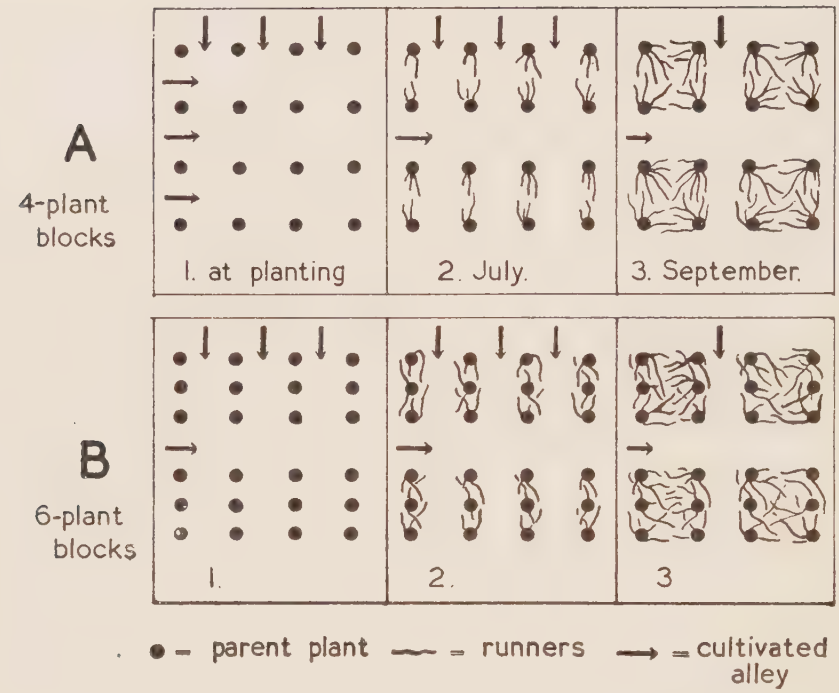


FIG. 1.
Method of planting and runner laying in isolated blocks.

FIG. 2.
A good isolated-block runner-bed of Huxley M44 photographed August 18th, 1944.

during most of the season, but some hand weeding may be necessary towards the end of the summer. Good weed control is important as weeds can smother the runners and make roguing impossible. The aim should be to get the blocks filled up by a full cover of runners, under which conditions the weeds themselves are smothered out.

Nicotine Vaporizing.—The recently introduced vaporized nicotine method for control of strawberry aphid has been used on strawberry runners in the Nuclear Stocks Scheme. This work is undertaken by contractors and under favourable conditions has killed a very large proportion of aphides. It is therefore a very desirable safeguard if clean runner beds become infested with strawberry aphid. The times when it is likely to be necessary are after the migratory periods of the strawberry aphides. Research is still proceeding, but experience so far suggests that the latter part of June is the most important time for vaporizing runner beds. Partial control of strawberry aphides in the field can also be obtained by spraying with nicotine 8 ozs., soft soap 8 lbs., water 100 gallons. At least two applications are necessary.

Roguing.—Successful roguing depends on the inspection of the plants at times when virus disease symptoms are clearly visible. These periods may vary from year to year and it is important to look at the plants regularly so that the best times may be chosen for roguing. The two virus diseases at present of importance are Yellow-edge and Severe Crinkle. Yellow-edge generally has the most severe effects, but Severe Crinkle is also of great importance.

Severe Crinkle.—On the young leaves of Crinkle-infected plants small chlorotic spots develop, which do not grow, and as a consequence the leaves become distorted and crinkled. The severity of the distortion of the leaves depends on the number and size of these chlorotic spots. In severe cases the spots increase considerably and develop a brownish purple necrotic centre, and the leaves are badly distorted in consequence. The petiole does not seem to be much affected and the plant therefore remains more or less domed. Crinkle symptoms usually become visible from April to May and reach their greatest intensity in June, when the first roguing should be carried out. Later in the summer leaf symptoms may fade somewhat, but become visible again in September when a second roguing should be made.

Yellow-edge.—The young leaves in the centre of the plant are first to show signs of the disease. Chlorophyll is deficient in the margins of the young leaflets and these therefore have a yellow edge. Moreover marginal growth is restricted and cupping and curling of the leaflets results. The yellow edge is not hard and sharply defined but merges gradually into the green tissue of the leaf, giving a soft appearance which is quite distinct from the hard yellow line sometimes seen on leaves during a dry summer. The irregular and diminished growth of the young leaflets results in a dwarfing of the leaf as a whole, the leaflets become asymmetrical, and the leafstalk is abnormally short. If the attack is severe and there are many such leaves the whole plant presents a dwarfed and flattened appearance. Older leaves which developed before the plant began to show symptoms are quite normal in appearance.

Yellow-edge plants are generally less apparent in the early summer for symptoms may be masked under conditions unfavourable to rapid growth (such as cold weather or drought). Any Yellow-edge plant seen at the first roguing should of course be removed, but the best period for roguing Yellow-edge plants is from the middle of September to the middle of October. At any roguing each plant should be inspected by a competent observer and all plants showing virus symptoms must be removed and immediately destroyed. After the runners have met, all plants in the block in which a diseased plant occurs must be removed. By this method all runners from a diseased plant and all others which have been in contact with them are automatically isolated and removed. Under normal conditions the percentage of plants removed, including also the plants removed for lack of vigour due to any other causes, has usually been less than 1 per cent., but it is important to keep the standard high. In the case of the tolerant varieties, any plants showing reduced vigour, flattening or visible symptoms of virus disease should be removed, and it must be realized that at best "tolerant" varieties can only be regarded as relatively virus-free. For good results, therefore, ruthless roguing of these varieties is necessary. Advice on roguing for virus diseases, and assistance in recognition of the symptoms in the field, may be obtained from County Horticultural Officers.

Tarsonemid mite (*Tarsonemus pallidus* Banks).—This pest should be unlikely to occur in a Special Stock runner bed, but may occasionally do so, and can then only be dealt with by drastic roguing. Infestation by Tarsonemid mite produces flattish plants with yellowish dried-looking leaves (Massee, 1935), and the mites and their eggs may be seen with a lens, in the folds of the young leaflets. Besides weakening the plant, it makes effective roguing for Yellow-edge impossible. Fortunately the isolated block method makes it possible to remove affected blocks before neighbouring blocks become infested, for the mite is a slow traveller. No other field control is at present available. The mite may be killed, on runners before planting, by the warm water treatment (Rogers, King and Massee, 1939), but as this has rather drastic effects on the plants themselves, the best policy is to ensure that only mite-free stocks are selected for planting.

FIG. 3.
Royal Sovereign showing Yellow-edge symptoms.

FIG. 4.
Royal Sovereign showing Severe Crinkle symptoms.

Lifting, Grading and Marketing.—Times of lifting vary in different parts of the country and with the markets served. In the west where rainfall is high and growers plant early, lifting may begin in August, but this would generally involve a large wastage of plants as many runners will not have rooted. Royal Sovereign in particular does not reach its maximum runner formation until September, so that early October lifting is more generally economic. At this time of year an extra week and a slight rain will make a considerable difference to the condition of the runners. As far as possible lifting should be carried out in fine open weather, or too much soil will adhere to the roots. The usual procedure is for men to work down the rows of blocks loosening the runners with forks, while women follow behind cutting the stolons from the parent plants and from each other, and loading into boxes. The boxes are taken to the packing shed, or to a table erected in the field, for trimming, grading, bunching, and packing. The stolon is cut away close to the runner plant and dead leaves removed. Some growers make two grades, firsts and seconds, but one grade, from which all very big plants and all with small crowns and root systems of less than 2 inches long are discarded, is quite satisfactory. The very large runners which can only be successfully planted with a trowel are most suitable for sale to gardeners. Careful supervision of the grading is necessary to ensure that the standard is maintained. After grading, the runners are bunched—25 plants to the bundle being usual—and packed into wooden crates, egg boxes, or some other rigid container. At present, suitable containers are very difficult to obtain, but in any event sacks are not recommended, even for short journeys. Moisture and ventilation are the two requirements. If there is too much ventilation the runners will dry out, but too little causes heating, and this must be given particular attention when sending plants long distances. Before they are packed the bundles should be lightly sprayed over with water, and all surplus moisture shaken from the leaves ; they are then laid in the boxes with their roots towards the centre and a layer of damp moss, hay, wood-wool, or peat placed over the roots. An important point here is to make certain that the packing material is thoroughly damp, otherwise it will absorb moisture from the roots during the journey. Peat needs soaking for several hours to wet it properly. The box can be finished off with a layer of hay or straw, roped round to hold the straw in position; or wooden slats can be used. Boxes to hold 250, 500, and 1,000 plants are useful sizes. Lifting, packing and transport are most important factors, and healthy runners are worth a good deal of care in this respect.

Runners must not be exposed to drying winds at any period, and if it is necessary to leave lifted plants for long, they should either be heeled in or covered up. The best plan is to arrange so that runners are dispatched not later than the day following lifting. Runners should be sent by passenger train, and timed to arrive so that they can be planted immediately, i.e. avoiding week-ends if possible. Lifting usually continues until mid-November and the grower should ensure that he has adequate labour to market the runners in the time available. Some delay by frost and rain should be allowed for. Spring lifting usually extends from February to April ; drying winds are particularly troublesome in March. It is possible to keep the best of the runners which are too small for marketing in autumn, but which have roots about 1 in. to 1½ in. long, and to plant them closely in nursery rows, at about 2 in. × 8 in., to plump up for spring marketing. This has proved worth while, where labour is available, especially in late seasons.

The Life of a Runner Bed.—It is a condition of the Special Stock Certificate that runners shall be taken only from maiden plants (i.e. plants in their first year).

While it is possible to get big crops of runners from 2-year or older parents, various difficulties make it undesirable. Weeds, mildew and aphides are harder to control and the runners are somewhat smaller and weaker. It is not worth leaving old parent plants to fruit, as the crop weight will be small, owing to the wide spacing and weakening from runner production. The best plan is to treat runners as a one-season crop and plough in the parent plants immediately lifting is finished. The life of the runner bed, therefore, should extend, at most, from autumn of one year to spring, eighteen months later.

The Economic Aspect.—*Yields.*—Yields of Royal Sovereign grown under the isolated-block system have ranged from 30,000 to over 100,000 runners per acre. Usually many more runners are rooted and marketable in the spring than in the autumn, but as autumn planted strawberries give a better performance, the greatest demand is for such plants. Autumn lifted plants therefore rightly command a higher price.

It is difficult to quote accurate costs of production, but figures based on actual working of some nurseries show that, including cost of parent plants and nicotine vaporizing, about £116 per acre covered the cost in the early years of the war.

Labour.—We have found that one man on the job continuously from spring to autumn can do most of the work on one acre of runners. Extra labour will be required at lifting time. It is advantageous to have one or more men specially trained and responsible for the runner raising, rather than large gangs of casual labour placed on the field at long intervals. Careless hoeing especially can be very harmful to strawberry plants.

The Acreage Required.—To maintain 12,000 acres of strawberries in fruiting (the approximate acreage existing in England and Wales in 1941), about 4,000 acres need to be planted annually. This requires about 48 million runners per annum. To raise this number in " isolated block " runner beds at a production of 50,000 runners per acre would require 960 acres. It is probable that nothing like 960 acres are specially planted for runners at present, and that many runners are taken from maiden plants that are planted closely for subsequent fruiting. Often 100,000 runners per acre can be taken in this way, though with considerable sacrifice of fruit in the following years, and with reduced chance of roguing for disease. To plant up with " isolated block " produced plants, an area sufficient to produce 48 million " once grown " plants raised in this way, would need only 116 acres. The " isolated block " plants should qualify for the Ministry of Agriculture's new Special Stock Certificate, and runners raised in closely planted commercial rows would qualify under suitable conditions for the Ministry's ordinary certificate.

Acknowledgements.—The authors acknowledge with thanks the advice and assistance of Mr. R. V. Harris, Mr. I. W. Prentice, Dr. A. M. Massee, and Dr. G. H. L. Dicker in the sections concerning virus diseases and pests.

Summary.—1. Details are given of the methods recommended for the production of healthy runners, with special reference to avoidance of virus diseases.

2. Treating runner raising as a specialized business, to be conducted in areas away from the main strawberry growing areas, is advocated.

3. Virus-tested stocks and the " isolated block " cultural system should be used. " Virus sensitive " and " virus tolerant " varieties must not be raised at the same centres.

4. Notes are given on varieties and stocks, locality, cultural methods, choice of field, preparation of ground, planting, manuring, deblossoming, mildew control, laying in of runners, cultivation and hand weeding, nicotine vaporizing, roguing for Yellow-edge and Severe Crinkle, lifting, grading and marketing, and the economic aspect.

5. To maintain the 1941 acreage of strawberries in England and Wales entirely from isolated block runner beds would require about 960 acres, or to maintain the supply with " once grown " plants from isolated block parents would require 116 acres.

References.

Harris, R. V. (1933). " The Strawberry Yellow-edge Disease." *J. Pomol.*, **11**, 56-76.

——— (1937). " Transmission experiments with Crinkle." *Rep. E. Malling Res. Sta. for 1936*, 212-21.

Harris, R. V. and King, M. E. (1942). " Studies in Strawberry Virus Diseases. V. The use of *Fragaria vesca* L. as an indicator of Yellow-edge and Crinkle." *J. Pomol.*, **19**, 227-42.

King, M. E. and Harris, R. V. (1942). " Studies in Strawberry Virus Diseases. IV. Symptom expression of Yellow-edge in the variety Royal Sovereign." *J. Pomol.*, **19**, 212-26.

Massee, A. M. (1935). " On the transmission of the strawberry virus ' Yellow-edge ' disease by the Strawberry Aphis together with notes on the Strawberry Tarsonemid Mite." *J. Pomol.*, **13**, 39-53.

Massee, A. M. and Greenslade, R. M. (1941). " Work at East Malling on the control of the strawberry aphis." *Rep. E. Malling Res. Sta. for 1940*, 92-4.

Rogers, W. S., King, M. E. and Massee, A. M. (1939). " Results of Researches in Strawberry Growing." *Sci. Hort.*, **7**, 71-84, and *Rep. E. Malling Res. Sta. for 1938*, 223-34

THE AMATEUR'S FRUIT GARDEN

By H. M. HUGHES

The acquisition of Bradbourne House with its spacious walled garden provides an excellent opportunity to demonstrate to the amateur the results of years of research on fruit growing. Although the fundamental principles of fruit growing apply to the commercial grower and amateur alike there are certain aspects and problems that are of special interest to the latter, and it is hoped to investigate these at Bradbourne.

Possibly the main difficulty for the amateur is lack of space and the need to obtain worth-while crops from quite small plots. The importance of a *planned* lay-out cannot be over-emphasized, and the following main considerations should be borne in mind when planning the fruit garden.

1. The considered planning of the garden.
2. The economic utilization of ground, wall and fence space, without overcrowding.
3. The correct grouping of kinds and varieties of fruits.

4. The selection of suitable rootstocks for the tree fruits.
5. The choice of reliable cropping varieties, mainly dessert, to provide fruit over as long a period as possible.
6. Routine work, including pruning, spraying, manuring, bird protection and cultivations.

The fruit garden carefully laid out will be easy to run and will provide a good selection of fruits throughout the season. Even the smallest plots will repay wise planning, in fact they need more care than the larger plots. It is possible to obtain apples, raspberries, gooseberries and currants from the same area that is covered by one spreading Bramley tree in the unplanned garden.

In order to save space, pears, red currants, gooseberries and the cane fruit can be trained against walls and fences and the latter are suitable also for apples ; the extra warmth and protection given aids in the production of first quality fruit. Fruit should always be grouped in rows or blocks, keeping the different kinds together, so that individual spraying and manuring can easily be given. The fruits requiring bird protection should also be planted so that it is convenient to erect a cage or net them over. Whilst it is best to keep kinds of fruit grouped in this way, it is not always practicable, and it is then important to plant together those kinds that need the same manuring and tolerate the same sprays. Thus black currants can be planted with plums or pears, and red currants or gooseberries with apples. Vegetables and strawberries should not be grown amongst established fruit trees after the first few years as the cultivations required injure the fruit roots and the crops exhaust the soil. Strawberries require well manured ground and replanting every three years, and are best grown in the vegetable garden rotation.

Where space is very limited priority should be given to currants, gooseberries and raspberries for quick returns and compact growth. Apples (on dwarfing rootstocks) and loganberries also give good crops. Pears, plums and morello cherries by comparison are rather uneconomic of ground and should only be included where there is adequate room.

It is essential to obtain varieties on the correct rootstocks. The effect of the rootstock on cropping and size of tree has been investigated at the Research Station and it is clear that certain rootstocks can save much labour in gardens. The trees on suitable rootstocks such as M. IX or M. VII that crop precociously, submit meekly to pruning and remain the ideal size for gardens, compare favourably with the trees on unknown rootstocks, over vigorous, all-wood-and-no-fruit so often seen in gardens, trees that should have received constant attention in the form of ringing and root pruning to keep them within bounds.

The choice of varieties depends on personal preferences and the locality, but it should be remembered that certain varieties are completely self-sterile and need pollinating from adjacent trees if they are to set a crop. If only one tree is required a self-fertile variety must be chosen (see reference 4). Some varieties cannot be recommended as they are unreliable croppers or very vigorous growers or especially liable to certain pests or diseases, or spray damage. At present owing to a shortage of layered rootstocks nurserymen have agreed to propagate chiefly certain " approved " varieties of apple, of which those listed below are suitable for small gardens.

Culinary.		*Dessert.*
Edward VII.	Cox's Orange Pippin.	Epicure.
Grenadier.	Miller's Seedling.	Fortune.
Monarch.	Worcester Pearmain.	Allington Pippin.
Early Victoria.	Laxton's Superb.	Ellison's Orange.
Lane's Prince Albert.	Charles Ross.	James Grieve.
	Lord Lambourne.	

In a small area there is seldom room for culinary fruit, but a few cooking apples on M. IX rootstock may be included. Where there is room, the best of the preserving varieties, particularly plums, currants and raspberries, should be grown to provide sufficient quantity of fruit in the ideal state for preserving.

Pests and diseases can be brought into a garden on new plants, so care should be taken to buy clean stock. In particular advantage should be taken of the Ministry of Agriculture's schemes for the " certification " of black currants, strawberries and Norfolk Giant raspberries. A list of growers who sell certified disease-free plants can be obtained each autumn from Ministry of Agriculture, Berri Court Hotel, Lytham St. Annes, Lancs., and it is strongly recommended that amateurs should follow the lead of commercial growers, who have found it well worth while to buy only these healthy strains and to keep them clear of old infected material, which should preferably be burnt before the new material is planted. Garden and allotment societies could order in bulk for their members, and the Women's Institutes generally make arrangements for the bulk purchase of certified black currants.

Three Demonstration Amateur Fruit Plots.—A part of the Bradbourne garden was divided by spile fencing into three small plots, of sizes that might be devoted to fruit growing in the garden of average size. The plots were designed to show :—

1. Economic utilization of ground.
2. Grouping and arrangement of fruits.
3. Distances of planting kinds of fruit.
4. Selection of suitable varieties and rootstocks.
5. Different methods of training fruit for small areas.

The varieties were chosen by the pomologists of the Research Station and include many of the best quality fruits. Not all of these may be obtainable but alternatives can be suggested. The fruit was planted in 1944. The gardens show what may be achieved from small areas. It should be realized that no plan is rigid but must be adjusted to suit each garden. Enquiries from amateur growers will be welcome.

The following rootstocks were chosen :—

Apples : M. IX.
Pears : Quince C.
Plums : Common Mussel or Common Plum.
Cherries : Mazzard.

These rootstocks are suitable for most garden soils in reasonable condition ; on very light, chalky or clay soils other rootstocks may give better results and information is available on request.

The black currants and Norfolk Giant raspberries and the temporary intercrops of strawberries are " certified " stock as recommended. Each garden is briefly described with lists of the varieties grown and the distances of planting ; the scale plans show the lay-out. Notes to follow will describe the routine pruning, spraying and other necessary operations. The plans can be easily adapted to gardens of differing sizes by altering the number of the different fruits grown.

Garden I (45 ft. × 68 ft.) is the largest of the three plots and was designed to give a good selection of choice varieties for a household of three to five persons. The pear and apple cordons provide a wide choice of varieties from a small area. The rows run north-south to obtain full benefit from the sun. Four galvanized wires at approximately 2 ft., 3 ft. 6 in., 5 ft., and 6 ft. 6 in. from the ground are strained by means of easily adjustable eye bolts from angle irons embedded in concrete. An inner iron strut at each end post is necessary to take the strain. This provides a tidy and durable method of support ; the irons should be kept painted to prevent rusting. Gas- or asbestos-piping or concrete posts can also be used. Wooden posts well seasoned and dipped in preservative are cheap and generally obtainable ; if embedded in concrete they have a longer life. The trees are planted at a slight angle to the north and to the leaward side of the wirework to prevent wind damage. Bamboo or hazel canes are secured to the wires at an angle of 45° and the trees trained to these ; this prevents chafing on the wires, and the leader shoots can be tied down throughout the summer growing season. The cordons will be re-tied down at 30° with ground level when they reach the top wire. It will be noticed that owing to the length of the tree when at this acute angle, the last tree must be at least 8 ft. from the end post and the end spaces should be filled by branches trained from the first and last cordons. Cordons are not suitable for very short rows where espaliers are more profitable. Both provide useful screens or edges along paths.

The loganberries on the fence are carefully trained during the summer so that the young wood is brought above the old wood, to reduce the danger from Cane Spot disease. The Himalayan Giant blackberry is a very strong grower and could be used for shielding a compost heap. Also growing against the fence are triple cordon gooseberries, trained up vertical bamboo canes 1 ft. apart. These will need summer pruning of the side shoots but, once established, give well ripened dessert fruit.

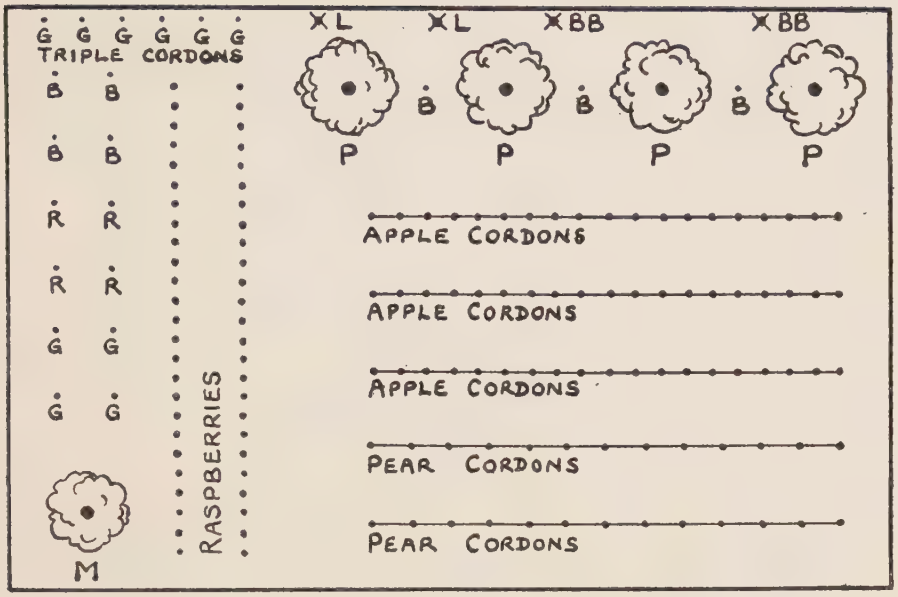
The bush fruit is planted in rows for easy protection from birds by means of a movable wire cage. The currants and gooseberries in all the gardens are planted at the minimum distance of 4 ft. × 5 ft. ; when fully grown there will just be room for hand cultivations between the bushes. The black currants interplanted with the plums can tolerate some shade, and both fruits appreciate nitrogenous manures and fertilizers. The plums were carefully chosen to provide suitable pollinators for each other. These are standards, i.e. grown on a 6 ft. leg and securely tied to a stout post to prevent wind damage.

The morello cherry is liable to exceed the ground allotted it if not kept in check by routine disbudding and pruning when established. Sweet cherries are totally unsuitable for small gardens and cannot be included as they grow too vigorously and cannot be checked by training.

Owing to the rapidity and ease of spread of the raspberry virus diseases it is not at present possible to include the two varieties of raspberries listed as these would be a danger to an adjacent raspberry propagation bed. At present a temporary crop of strawberries is taken until the raspberries can be planted. In Gardens II and III the variety of raspberry is " Norfolk Giant " which can be selected for freedom from virus disease and therefore there is no risk of spreading infection.

Garden II is only half the size (30 ft. × 45 ft.) of Garden I, but an endeavour is made to obtain a wide selection of fruits. Advantage is taken of the spile fence to train single U cordons of gooseberries

FENCE



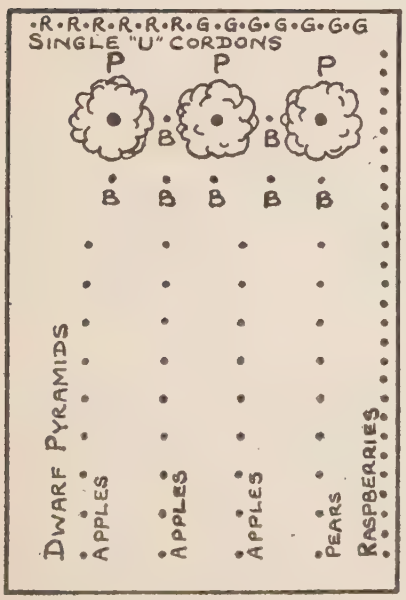
GARDEN I.
45 *ft.* × 68 *ft.*

Key :

R—Red Currant.
G—Gooseberry.
B—Black Currant.
BB—Blackberry.
M—Morello.
P—Plum.
L—Loganberry.
· = Raspberry.

Scale 0 3 6 9 12 ft.

FENCE



GARDEN II.
45 *ft.* × 30 *ft.*

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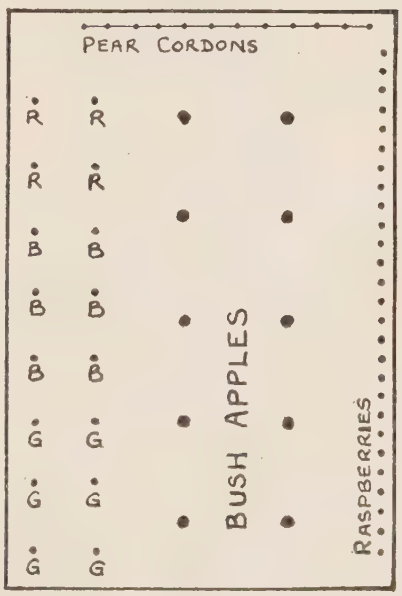

GARDEN III.
45 *ft.* × 30 *ft.*

[*Diagrams by Miss E. C. Thompson.*

List of Varieties in Gardens.

	Garden I. 45 ft. × 68 ft.	Garden II. 45 ft. × 30 ft.	Garden III. 45 ft. × 30 ft.
Strawberry ..	Royal Sovereign (M.40)	—	—
Raspberry (·) ..	*18 in. × 5 ft.** Preussen Lloyd George	*18 in. × 5 ft.* Norfolk Giant	*18 in. × 5 ft.* Norfolk Giant
Black Currant (B)	*Bush 4 ft. × 5 ft.* Seabrook's Goliath Baldwin	*Bush 4 ft. × 5 ft.* Baldwin Seabrook's	*Bush 4 ft. × 5 ft.* Baldwin Goliath
Red Currant (R)	*Bush 4 ft. × 5 ft.* Skinner's Early Laxton's No. 1 Chenonceau	U-*Cordons 2 ft. apart.* Skinner's Early Chenonceau La Constante Wilson's Long Bunch	*Bush 4 ft. × 5 ft.* Skinner's Early Laxton's No. 1
Gooseberry (G) ..	*Bush 4 ft. × 5 ft.* ɯ *Cordons 3 ft. apart.* Keepsake Leveller Gunner Leader Howard's Lancer Cousen's Seedling White Lion	U-*Cordons 2 ft. apart.* Gunner Leader Lord Derby White Lion Warrington May Duke	*Bush 4 ft. × 5 ft.* Leveller Gunner Howard's Lancer Keepsake Lancashire Lad Cousen's Seedling
Apples (Culinary) ..	*Cordons 2 ft. apart.* Arthur Turner Rev. Wilks Stirling Castle Lane's Prince Albert Edward VII.	*Dwarf Pyramid 3 ft. ×6 ft.* E. Victoria Rev. Wilks Lane's Prince Albert Edward VII.	*Bush 8 ft. × 8 ft.* E. Victoria Lane's Prince Albert Edward VII.
(Dessert) ..	Owen Thomas Epicure James Grieve Lord Lambourne Fortune St. Edmund's Russet Ribston Pippin Cox's Orange Pippin Egremont Russet Orleans Reinette King's Acre Pippin Wagener	Owen Thomas James Grieve Ribston Pippin Cox's Orange Pippin Egremont Russet King's Acre Pippin	Owen Thomas James Grieve Cox's Orange Pippin Egremont Russet King's Acre Pippin
Pears	*Cordons 3 ft. apart.* Doyenné d'Été Laxton's Superb Williams' Bon Chrétien Beurré Superfin Fondante d'Automne Durondeau Conference Doyenné du Comice Thompson's	*Dwarf Pyramid 3 ft. ×6 ft.* Laxton's Superb Williams' Bon Chrétien Fondante d'Automne Conference Doyenné du Comice	*Cordons 2 ft. apart.* Laxton's Superb Fondante d'Automne Conference Doyenné du Comice Thompson's
Plums (P) ..	*12 ft. apart.* Victoria Denniston's Superb Gage Golden Transparent Gage Frogmore Damson (on Common Mussel only)	*10 ft. apart.* Early Laxton (on Common Mussel only) Victoria Denniston's Superb Gage	
Cherry (M) ..	Morello		
Blackberry (BB)	John Innes Himalayan Giant		
Loganberry (L)	Loganberry (true)		

* See p. 96.

and red currants at 2 ft. apart, and the black currants are interplanted under the three plum trees. A net can be hung over the gooseberries and red currants against birds, whilst black currants seldom need protection. The main area of the garden is devoted to dwarf pyramid apples and pears. This method of training allows the same number of trees and therefore as wide a choice of varieties per area as cordons, but there is no need for support. The trees are pruned in winter and summer to form a self-supporting shape and to make full use of the ground. The raspberries are tied up to a spile fence, thus saving space ; they should be desuckered carefully to prevent suckers growing up in the next garden. Norfolk Giant is a good preserving variety, although not one of the best for dessert, but it is the only variety that can be obtained disease-free at present, from growers of " Certified Stock ".

From **Garden III** the novice or the person with little time or inclination for gardening should be able to produce useful crops with the minimum of work. The ten bush apple trees on M. IX require only a simple winter pruning to produce fruitful trees which when in full bearing, after 6 to 8 years, will give a total 4-6 bushels of fruit, without exceeding the 8 ft. × 8 ft. planting distance. Only M. IX rootstock is suitable for dwarf bush culture. The gooseberries are grown as stools retaining any strong basal shoots and not keeping a clean 6 in. stem or " leg " as in the other gardens ; the only pruning required is a general thinning out of shoots each winter. The pear cordons trained on the spile fence are here planted at 2 ft. apart since a path and the fence will restrict growth ; summer pruning will be needed here as well as the usual winter spur pruning, to obtain fruitful spurs.

In this little plot all the fruit has light and root room and, although the plot may look sparse in the first 4 to 5 years after planting, when once fully grown the wisdom of resisting the great temptation of all amateur gardeners—overcrowding—will be apparent. The fruits are within easy reach for the 2-3 routine annual sprays which can be satisfactorily applied with a hand sprayer, and the pruning is reduced to a minimum. An annual autumn forking followed by hoeing in the spring and an occasional dressing of compost supplemented by artificial fertilizers will keep the fruit vigorous and healthy and in regular bearing. The newcomer to fruit growing might well start with a fruit plot laid out to a similar plan, but if the increasing interest in the more intricate methods of training fruit trees and the desire for apricots, peaches and the choicest of all varieties lead past Garden III plan, the problems overcome and the work provided will give stimulating and lasting interest for many years.

Leaflets for further information—

BAGENAL, N. B. " Fruit growing in Small Gardens." *Country Life,* Home Front Series No. **5** 9d.
HATTON ,R. G. " An Amateur's Fruit Garden." Reprint from *J. Royal Hort. Soc.,* lxviii, December, 1943, pp. 361-74. 6d.
POTTER, J. M. S. " Fruit from the Garden." Growmore Bulletin No. **7**. 3d.
" The Fertility Rules in Fruit Planting." Leaflet No. **4**. John Innes Horticultural Institution, 31 Mostyn Road, S.W.19. 6d.

THE PRESENT POSITION REGARDING THE DIAGNOSIS OF MINERAL DEFICIENCIES IN FRUIT TREES BY PLANT ANALYSIS AND PLANT INJECTION

By W. A. ROACH

Introduction.—This note* describes briefly two complementary methods for diagnosing mineral deficiency in plants. In the first a few leaves from unhealthy trees are analysed and compared with those from similar but healthy trees ; in the second the effect of increasing by injection the amount of selected elements is studied, each in a different small part of the plant. Thus, the first method determines what the plant has actually obtained from the soil and the second can be used to find out whether an increase in the supply of any of the elements would be advantageous to the plant.

For the diagnosis of mineral deficiencies several methods are necessary to suit different circumstances and the two to be described here are used in conjunction with visual symptoms, as described by Professor Wallace, and with an examination of the soil by chemical and other means. A realization of the limitations of the various methods is as important as a clear idea of their possibilities, and an attempt will be made to indicate these for the two methods under consideration.

* This note is a summary of a talk at an Orchard Conference held in October, 1943, at the Essex Institute of Agriculture.

Diagnosis by Plant Analysis.—The analytical method of diagnosis must obviously be based on a knowledge of the minimum quantity of each element necessary for efficient commercial performance of the type of plant in question. This is obtained by analysing a large number of healthy, as well as unhealthy, specimens.

The composition of the leaves of healthy fruit trees is strikingly similar, no matter where they are grown, or whether they are apples, pears or plums, etc., whereas between neighbouring healthy and unhealthy trees there are commonly wide differences in composition. A good example is furnished by a small group of extravagantly manured Japanese plum trees of outstanding healthy appearance growing in a South African plantation. The mineral composition of their leaves was practically identical with that of the healthiest trees known to us in this country, whereas leaves from unhealthy trees growing within 20 feet of them showed wide differences in composition.

The economic importance of deficiencies of nitrogen and potassium in fruit is well known, but the need for phosphorus is less than in most agricultural crops. The fact is not as generally realized as it should be that calcareous dressings (lime, lime-stone, chalk, gypsum, etc.) often make good a deficiency of calcium and that this effect may be even more important than the better known effects of "lime". In addition, economically important deficiencies of magnesium, iron, manganese and boron have been reported in various crops in Britain. Deficiencies of zinc and copper have also been detected; though not yet proved to be of economic importance in this country, they are of supreme importance in many places overseas, where they have caused death or serious damage to trees over wide areas.

Of these ten essential elements all except nitrogen and copper are already covered by routine analysis at East Malling and as there is an obvious advantage in having the routine analyses complete for all the essential elements, it is hoped to add these two and other elements (e.g. nickel) to the list shortly. To make these analyses in reasonable time on leaf samples of reasonable size it has been necessary to abandon older chemical methods and to work out new ones. One of these, a spectro-chemical method, may be mentioned.

The leaves are first cleaned by rubbing with muslin, dried and powdered. Then 0·025 g.(i.e. about 1/100 of a teaspoonful) is wrapped and compressed inside specially pure paper and burnt in an oxy-acetylene flame in front of a spectrograph. In the flame each element emits light of characteristic wavelength or colour, and in the spectrograph this light is separated, according to wavelength, and photographed as a series of lines. The greater the amount of an element the blacker and broader is the corresponding line, and this density of line is used to measure the amount of the element present. These photographs of all the lines of light from a sample are called spectrograms. By making spectrograms of unhealthy and healthy leaves side by side on the same plate it is often possible to diagnose a deficiency merely by glancing from one spectrogram to the other and noting the differences in line densities. Thus, if the lines for calcium, potassium, manganese, iron or magnesium are below a certain density a deficiency of the element in question is indicated.

If, however, the calcium lines are abnormally dense, indicating an abnormally high amount of this element, the interpretation of results is not so simple, because an excess of calcium interferes with the proper uptake and utilization of the trace elements. Consequently, the presence of a normal or even of an abnormally large amount of any one of these elements (iron, manganese, zinc or boron) is by no means a sure indication that the plant is adequately supplied with the element in question. Iron, in particular, is often present in more than normal amount in leaves that are completely yellow and develop a healthy green colour when injected with ferrous sulphate or some other suitable iron compound. In the yellow leaf the large amount of iron present appears to be in such a condition that it is useless to the plant. No definite diagnosis for plants with high calcium content can at present be based solely on plant analysis, for even if one trace element is low in amount, others, present in normal or large amounts, may be in a condition making them useless to the plant. Because this condition is brought about by excess of calcium it is known as "lime induced chlorosis". For such cases plant analysis must be supplemented by some other method of diagnosis. One of these is plant injection.

Diagnosis by Plant Injection.—Diagnostic plant injection consists in introducing each substance to be tested into a selected part of the plant and observing its effect by comparison with a similar neighbouring untreated part of the plant. The methods have been described in detail elsewhere.*

The general principles underlying the methods and some idea of how they are carried out will now be given.

Most methods of plant injection are based on the fact that, whereas we bleed when cut, plants rarely do so; on the contrary, they usually absorb any watery liquid bathing a cut or broken surface.

* *Plant Injection for Diagnostic and Curative Purposes*, by W. A. Roach. Price 5s. Published by Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent. Obtainable from IAB. Central Sales Branch Agricultural Research Building, Penglais, Aberystwyth.

Moreover when the animal is injected the liquid has to be forced in against the pressure of the blood, while the plant actually sucks up watery liquid supplied in a suitable manner and no pressure is necessary. It is unfortunate that the same word "injection" is used for two processes which are so opposite in this respect. For want of a better word, however, injection will continue to be used for the operation on plants as well as that on animals. There is a further difference between animals and plants of great importance for our present purpose. Liquids injected in the animal are carried very rapidly in the blood stream to every part of the body. The plant lacks anything to correspond with the circulation of the blood, and liquid injected into it travels much less freely than in the animal; the direction and extent of its movement can be predicted and to some extent controlled by selection of the position of the injection point. Advantage is taken of these facts in the various diagnostic injection methods, a few of which will now be described briefly.

Interveinal Method.—The solution containing the element to be tested is held in a thimble-shaped vessel made from a cellophane drinking straw, to the inside of which a small strip of filter paper has been stuck. A chisel of about 1/16 in. wide, made from a scrap of safety razor blade suitably mounted, is used to make a cut through the leaf (e.g. an apple leaf) equidistant from two side veins and the central vein. The end of the filter-paper strip is pushed through the incision and the strip then acts both as a wick to carry the solution to the cut surface and as a support to the tiny reservoir. The liquid in the course of a few hours permeates the part of the leaf between the two side veins up to the central vein, but does not cross any of these veins. The effect of injecting, for example, an iron salt, into an iron deficient leaf is seen in the course of a few days as an improvement in the green colour of the area between the veins, in marked contrast to the untreated areas on either side. Such a response has on one occasion been obtained in two days, but usually about a week elapses before any response is visible. This method was developed for research purposes and is not recommended for the use of anyone but a neat-fingered expert.

Leaf-stalk Method.—This is the most generally useful diagnostic method. The blade of a leaf is cut off, using a suitably mounted piece of safety razor blade, and the leaf-stalk left attached to the shoot is bent downwards into a small glass tube containing the solution to be tested. The tube has fixed to it a length of lead wire which is twisted once round the shoot to hold the tube and leaf-stalk in position. The liquid is absorbed through the cut leaf-stalk and passes into a number of leaves above and below. In the apple, pear, plum and peach, the two leaves next above and the two leaves next below the cut leaf-stalk are permeated on the side of the leaf nearer the cut leaf-stalk but not on the further side. Thus in these four leaves the effect of the liquid can be studied by comparing the two sides of each of these four leaves. The diagnosis is usually made in about a fortnight, but the actual time elapsing before the full effect has become apparent has varied from five days to three weeks according to the kind of plant and growth conditions. The treated side of the leaf is usually of a darker healthier green, often noticeably larger and sometimes feels thicker than the untreated. When responses are obtained on trees showing no characteristic symptoms the difference between the treated and untreated halves of the leaves corresponds to that between a clear and a "muddy" complexion in the human being.

Improving the condition of the foliage is the first step towards making the whole tree healthy, and improving the yield and quality of the fruit. To experiment directly on the yield and quality of fruit a larger part of the tree must be injected.

Branch Method.—By this method branches of a tree may be injected each with a different liquid, which is held in a container attached to its branch and led from the bottom of the container through rubber tubing to a hole bored into the branch at a point about one-quarter the way up it.

Whole Tree Methods.—(*a*) *Liquid.*—The method for injecting whole trees with liquid consists in leading the liquid from a bucket or other suitable container supported on the crutch of the tree through rubber tubing to two (or for very large trees, three) holes of $\frac{1}{4}$ inch diameter bored into the main stem to a depth of about a quarter of the diameter of the stem. Enough liquid is usually absorbed by a tree in full foliage in one day, or even less if the weather is bright and sunny. Absorption is slower in cold wet weather. Little liquid is absorbed if injected in winter and as yet this method has only been applied in summer.

(*b*) *Solid.*—To apply this method to large trees, holes of $\frac{1}{2}$ inch diameter are bored at intervals of 3 inches round the circumference of the main stem; into each hole is pushed the requisite number of tablets of the solid and the hole is closed with a cork or other closure pushed in flush with the wood to facilitate healing. The holes must be bored neatly without tearing the bark or healing will be delayed. A special tube and piston are used for inserting the tablets and cork, both for speed in working and to prevent any of the solid falling on the bark. Solid injection is usually done in the winter but has been applied safely and successfully in the summer. If proper precautions are taken the holes heal in a growing season. This method has been used with success for elements such as iron and manganese that are required only in minute amount, but can hardly be used for potassium

or other elements needed in relatively large amounts. It has the advantage over the preceding method of requiring no water but has the serious disadvantage of causing many times as much mechanical damage to the main stem. This point will be referred to again later.

Results of Treatments Based on Diagnosis.—The value and reliability of a diagnostic method must be gauged by the extent to which curative methods based on it are successful. A few examples will now be given.

Workers in New Zealand, British Columbia, New Brunswick and Finland all found as a result of injecting a number of substances into apple trees that only boron compounds cured the trouble known as " corky core ". This led to the rapid development of methods (usually soil application) for the cure of a disease which was of major economic importance in these and other countries overseas.

Serious chlorosis is common in fruit trees growing on the ragstone escarpment in Kent. My attention was drawn to one of these areas by Mr. W. G. Kent, the Advisory Officer in Commercial Fruit Growing to the Kent Education Committee. Leaf analysis showed the trouble to be of the lime induced chlorosis type, a large amount of iron being present. The results of diagnostic injection showed that iron was the " deficient " element. A few trees were cured by applying trunk injection experimentally, and since then the grower has cured all his trees in this way. It is well known that the application of iron salts to highly alkaline soils of this type is ineffective ; spraying with iron in various forms was tried without success and injection remains the only commercial curative method.

For over thirty years experts had been trying to diagnose and cure a most serious chlorosis in cherry trees in the Sittingbourne area, and many hundreds of trees had been grubbed just when they should have come into full bearing. Leaf analysis showed that manganese was low in amount and responses were obtained to diagnostic injection of manganese sulphate. Hundreds of trees have been cured by solid injection. A recent paper by Duggan in the *Journal of Pomology* gives further details. The injection was done in winter or spring, and in the following summer the injected trees bore heavy crops whereas for some years previously the fruit had not been worth picking.

As already stated, this method of injection is by no means ideal because of the extensive mechanical damage to the trunk ; but a better method has not yet been devised. Injected liquid is not always absorbed by cherry trees, and soil applications and spraying have so far been ineffective.

Another case of manganese deficiency was established by these methods in peach trees in South Africa. Some hundreds of trees were cured by liquid injection at a cost of 2d. per tree, a full crop of peaches being gathered the next season from trees which had borne no crop for at least three years. Spraying with a mixture of lime and manganese sulphate solution in winter was also effective.

It will be noted that in some of the above cases soil applications were ineffective in curing the disease whereas whole tree injection was successful ; it is unsafe, therefore, to assess the validity of a diagnosis solely on the basis of the results of soil applications. The reason for the failures is that soil often reacts with salts applied to it. Applications of magnesium sulphate and sulphate of ammonia to the soil have resulted in an increased content of manganese and other trace elements in trees growing in the soil ; hence, the effect on the plant would not by any means be limited to that directly yielded by the substance applied to the soil. These complications are avoided by the two methods described in this note because they determine what the plant has actually obtained from the soil and how far additions of selected elements improve the health of the plant. Injection methods have the advantage of giving to the farmer actual demonstrations, on a small scale and in a short time, of what the effect of suitable commercial applications would be.

Plant analyses of the type mentioned in this note are best carried out in a specially equipped laboratory and no fruitgrower is likely to attempt them ; but he may be tempted to try injection methods. The best procedure to be followed when the application of these methods is contemplated is to get in touch with the Horticultural Adviser who can discuss the problem on the spot in all its aspects. Instructions are available. If plant injection is necessary the best procedure, at least in the first instance, is for an expert to pay visits in company with the Horticultural Adviser. It can then be decided how far the Horticultural Adviser or even the farmer can co-operate in the injection work.

Summary.—Two methods of diagnosing mineral deficiencies in fruit trees are described. (*a*) *Plant analysis*, which reveals what the plant has actually obtained from the soil, and (*b*) *Plant injection*, by which may be studied the effect on a selected part of a fruit tree of increasing the content of any nutrient or combination of nutrients.

The importance is mentioned of the " trace " elements, such as iron, manganese and boron, that occur in only minute amount in the plant.

The presence of less than a certain amount of each element can be interpreted as a deficiency of that element on the basis of analysis alone.

If calcium occurs in abnormally large amount there is a tendency for the trace elements to occur in the plant in forms of little or no use to the plant and a complete diagnosis cannot be made on the basis of analysis alone. Injection is one way of supplementing analysis in these circumstances.

Brief reference is made to various injection methods suited to different types of plants and different purposes. The treated part of the plant may be of almost any size from a single interveinal area to a whole tree.

By injecting branches or whole trees the effect of a nutrient on yield and quality of fruit can be studied without the complications inseparable from applying nutrients to the soil, when part of the added substance is absorbed by the soil and an equivalent amount of other substances liberated in a form available to the plant.

Some results of curative treatments, based on diagnoses made by plant analysis and plant injection, are given to show how far the methods are reliable in practice.

A REVIEW OF OUR KNOWLEDGE OF MINERAL DEFICIENCIES IN FRUIT TREES

By S. G. THOMPSON

FRUITGROWERS are so well aware of the economic importance of deficiencies of nitrogen and potash that most of the worst cases have already been remedied, but all growers will know of instances where fruit has failed to grow or to crop, and many are aware that the failure has often proved to be due to some form of mineral deficiency other than nitrogen, phosphorus or potash ; few, however, are as yet fully conversant with the subject which may appear very large and complicated if all the mineral deficiencies known to affect crops of all kinds in different parts of the world are described. But if we confine ourselves to deficiencies of proved practical importance in this country it is only necessary to be familiar with three that are known to be common, and to realize that others are possibilities which research workers in this field are actively investigating.

The importance of a sufficient and balanced supply of the three main nutrients (nitrogen, phosphates and potash) and an adequate supply of lime, for satisfactory growth and cropping, has long been well understood. That these are not the only nutrients needed for full production is not so well appreciated, partly because research and field trials on the major nutrients have been going on for 100 years, whereas research on the so-called " trace " or " minor " elements is comparatively recent. As " minor " might imply that these elements were of small importance, whereas in fact they are as necessary to plants as the " major " elements, it is better to call them " trace " elements, which expresses the fact that they are needed by plants in very small amounts. This work on deficiencies of trace elements has now reached a stage when the lessons learned should be passed on to practical men.

The question may be asked, " Do these trace element deficiencies really affect the Profit and Loss account of the average well-managed fruit farm ? " The answer, even based on our present knowledge, which, it should be appreciated, is rapidly extending, is unquestionably " Yes ". Troubles due to deficiencies in England are not, it is true, of the serious and sometimes devastating kind that occur in other countries, but we know that they are widespread and cause serious economic losses; we also now know how to detect them, on what types of soil they are particularly likely to occur, how their occurrence can, to some extent at least, be avoided, and some practical and economic methods of cure.

To understand why mineral deficiencies do occur it should be remembered that plants build up the greater part of their bulk from the soil water and from the air, and part of their requirements is satisfied by adequate light and moisture. They also require a number of nutrients, in the form of salts, dissolved in the soil water, which they absorb through their root hairs. We usually concern ourselves only with three major nutrients, nitrogen, phosphates and potash, which as Liebig showed 100 years ago, are essential to growth. But plants also need calcium and magnesium in comparatively large amounts, and a long list of other elements in comparatively small, or very small, amounts. In a fertile soil, these other elements are present in sufficient quantities, and the reason why some soils are infertile is in some cases that one or more of these elements are not present in sufficient quantity, or alternatively are present but are in an unavailable form.

We can distinguish, then, between cases where one or more trace elements are not present in sufficient quantity, which might be called " real " deficiencies, and those where there is no such " real " deficiency but where the elements in question are rendered unavailable either in the soil or in the plant itself by excesses of some other element ; these are known as " induced " deficiencies.

If there is a real deficiency, it would seem easy to correct it by adding a sufficient quantity of a salt of the missing element to the soil, and this is sometimes the case ; good illustrations showing also

the small quantities of some elements required are the cobalt deficiency trouble in New Zealand and Scotland where as little as one pound of a cobalt salt per acre will convert pasture dangerous to sheep and lambs into one on which they remain healthy, and failures of pasture in S. Australia due to deficiency of molybdenum, which can be corrected by 1 lb. per acre of a molybdenum salt.

Induced deficiencies are, however, much more common than real deficiencies and are usually more difficult to correct by soil applications, and it is this type which is generally met with in fruit.

The Diagnosis of Trace Element Deficiencies.—In the past, when crops of any kind have consistently done badly or failed, the practical man has naturally concluded that the soil was unsuitable, and has concentrated on finding a crop to suit the soil, or in extreme cases, has abandoned the land as not worth cultivation. We now know, that although all plants have the same general requirements, some are more dependent than others on particular nutrients, and that they differ widely in their power of extracting these nutrients, it is no longer necessary to condemn a soil as infertile since it may be possible to discover and correct the cause of the infertility.

Our first step must be to decide whether we are dealing with a deficiency problem at all, or whether the poor performance of a crop is due to physical causes, to bad drainage, an impervious subsoil or hardpan, to some fungus, bacterial or virus disease or to insect or other pests ; if so it will be obvious how far matters can be improved, though it must be remembered that a plant or tree weakened by a minor element deficiency is easily attacked by disease. If no such physical cause or disease can be traced, the possibility that there is some mineral deficiency should be examined.

Our means of diagnosing deficiencies have developed rapidly in recent years, particularly since the commencement of war, and it is now possible to solve many problems which would have seemed insoluble even a few years ago. The main methods of diagnosis now being used are :—

1. *Soil Analysis.*—Soil analysis has been employed for the diagnosis of deficiencies of the major elements for a long time, and it is not the purpose of this note to discuss its possibilities and limitations ; it has not been employed extensively for the diagnosis of trace element deficiencies. Soil surveyors classify soils according to their origin, texture and other characteristics, and it is found that soils of certain " series " are liable to be deficient of certain minerals, including trace elements, so that a knowledge of soil survey results may be helpful.

As trace elements tend to be unavailable in alkaline soils, a knowledge of the reaction (or *p*H) is of importance ; their availability is also influenced by the amount and type of organic matter.

The soil analyst and surveyor can therefore give much information useful in solving deficiency problems.

2. *Analysis of Leaf Samples.*—The analysis of leaf samples, by chemical, spectrographic and polarographic methods which reveals what the plant has actually absorbed from the soil, has proved to be a valuable means of diagnosis, particularly when symptoms are doubtful or complicated, or when there is more than one deficiency. Such work can only be done in a specially equipped laboratory. Diagnoses cannot always be made by analysis alone, but it is a useful check on other means of diagnosis, and without analysis it is not possible to get a complete picture of a case.

Before submitting samples for analysis, the laboratory should be asked for instructions on how to take them : badly selected or contaminated leaves may lead to a wrong diagnosis.

3. *Plant Symptoms.*—Plants affected by mineral deficiencies often show characteristic symptoms which can be recognized by the skilled observer ; it is sometimes possible to say at a glance what the trouble is and to prescribe the appropriate cure. Those interested should consult the illustrated monographs on this subject* by Professor Wallace and American workers, but it should be emphasized that considerable experience is necessary to interpret symptoms correctly and that expert advice should be sought whenever possible.

4. *Plant Injection.*—While the first three methods are suitable for extensive use, plant injection is best suited for investigating cases not completely solved by them. The method should be employed by an expert, or under expert guidance. Those interested should consult a monograph on the subject.†

Curative Measures.—Having decided that a crop or a plantation is suffering from a particular mineral deficiency, the choice of remedy will depend on the type of deficiency and considerations of cost, labour and the time within which the treatment must be effective. We have the choice of soil applications, sprays, and for trees, solid or liquid injections.

As has already been said, when there is a " real " deficiency, soil applications, sometimes of very small amounts of the mineral element required, will suffice, but this will not be so with the commoner induced deficiencies when the required element is already present in the soil in adequate amount, but is not available to the plant ; even if we add more of the element, it too may be rendered

* *The Diagnosis of Mineral Deficiencies in Plants.* T. Wallace. H.M. Stationery Office, 1943, 116 pp.. 10s. *Hunger Signs in Crops.* A symposium. American Society of Agronomy. Washington D.C.

† *Plant Injection for diagnostic and curative purposes.* W. A. Roach. Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent. Tech. Comm. No. **10**, 1938, 78 pp.

unavailable. On field crops, sprays are often effective in supplying enough of a required nutrient for healthy development and cropping, and on fruit, sprays can effect remarkable improvement during a growing season if applied at the correct time ; cases have been reported where the improvement has been evident for at least the following year. In other countries, particularly America and South Africa, sprays of trace elements have become a regular part of fruit-growing practice. It is possible to add the trace element salt to one of the routine fruit sprays, so that there is little extra cost for time and labour ; but expert advice should be sought on the point.

Solid or liquid injections of fruit trees have restored health, growth, and cropping of very badly affected trees for several years. The process is simple and easily learnt and it is recommended for some serious deficiencies in preference to sprays.

There still remains the possibility of making an unavailable element available by appropriate chemical treatment of the soil, but this is usually so costly as to be merely of academic interest.

Fruit badly affected by trace element deficiencies sometimes recovers when the land is heavily stocked with pigs or poultry, when grassed orchards are ploughed, or when cover crops are grown and turned in on land which has been clean cultivated ; if any of these measures fit in with the farm programme they are worth trying. Recoveries often take place though no special treatment has been given, especially after vigorous growth has been made in a favourable season ; the explanation may be that the roots have reached a soil stratum containing the required trace element in an available form.

Fuller details of curative measures recommended for mineral deficiencies in fruit will be published in due course.

Induced Deficiencies.—It will be seen from what has already been said that the commonest problem is the correction of an induced deficiency, and some further consideration of how an excess of one element may make others unavailable is advisable.

The commonest and most important case is that of calcium (lime), which well illustrates the complicated nature of these relationships. On the one hand, calcium is itself one of the essential elements for plant growth, and lime has, of course, other valuable properties which make an adequate amount of lime essential for full fertility. On the other hand on land containing much lime, whether natural or artificial, deficiencies of several trace elements may occur and whether this will happen seems to depend on the presence or absence of sufficient humus of the right quality. A regular supply of decomposing organic matter appears to decrease deficiencies induced by excessive lime, whereas the dark brown to black humus in old garden soils or marshland appears to intensify deficiencies. Thus when a trace element is present in the soil in amount sufficient for normal growth, there may still be a deficiency, either because it is in a form the plant is unable to absorb (e.g. plants shown by analysis to be deficient in manganese, though manganese in the soil is high), or because the element becomes unavailable in the plant itself (e.g. plants which recover when sprayed or injected with an iron salt but which are shown by analysis to contain normal or even high contents of iron).

With regard to the lime problem it need only be said here that our present knowledge supports the old farming adage, " Lime and lime without manure makes both farm and farmer poor," in other words, lime is good but should be used in moderation, and the amount of humus should be kept up by any practicable means.

As compared with field crops, little research has been done on the lime requirements of fruit, and, in particular, there seems little evidence in support of the old belief amongst fruitgrowers that stone fruits require generous liming. As we have ample evidence of very serious damage done by over-liming fruit, and surprisingly little of good effects of liming, it would seem that the fruitgrower should be more conservative in his liming programmes than the general farmer.

After lime, the next most important cause of induced deficiency is probably excessive phosphate, which is known to " lock up " trace elements. Long continued heavy dressings of potash are known to be followed by symptoms of magnesium deficiency and fruitgrowers should note that though potash deficiency has in the past been the chief manurial problem of fruitgrowing in this country, the potash requirements of many soils have now been made good. Canadian workers state that heavy dressings of magnesium compounds, given to correct magnesium deficiency symptoms produced by excessive potash, produced in turn symptoms of calcium deficiency.

It will be seen that the lesson to be learned is the old one of " moderation in all things " : that dressings, whether of nitrogen, phosphate, potash or lime should not be applied without good reason or in excessive amounts : to do so is to waste money immediately and to run the risk of future deficiency troubles. Even in attempting to correct deficiencies the same rule applies ; thus boron deficiencies can be corrected satisfactorily by small dressings of boron compounds, but the limit of toleration is narrow and larger amounts can do serious damage for several years. Excessively clean cultivation also tends to accentuate deficiencies and should be avoided.

Deficiencies Known to Affect Fruit in England.—If other countries were included, a fairly long list

of trace element deficiencies affecting fruit could now be given, but several of these have not yet been met with in England. We need only concern ourselves at present with iron, manganese and magnesium, but we may note that indications of deficiencies of boron, zinc and copper are being investigated, and that there are other possibilities.

Iron.—Common on all calcareous soils and heavily limed field or garden soils. All fruits, including strawberries, may be affected ; apple, peach and raspberries are specially susceptible.

*Symptoms.**—Chlorosis (yellowing) particularly of the younger leaves.

Treatment.—Slight cases, i.e. when there are some leaf symptoms but no apparent effect on growth or crop, may best be treated by appropriate soil management, e.g. by cover cropping, turning in turf or any other method of adding humus, and by using acid, rather than alkaline manures. More serious cases, when effects on vigour and crop are already noticeable, can successfully be treated on a commercial scale, in trees, by either solid or liquid injections of iron salts ; the treatment is effective in one season and lasts for several years. Bush fruits and other crops can be sprayed, but expert advice should be sought, as iron sprays can cause much damage.

Manganese.—Recent work has shown that this deficiency is far more common and widespread than had previously been suspected, and the economic loss due to it, both in fruit and field crops, is undoubtedly great. Cherries are especially susceptible.

Symptoms.—Chlorosis, usually difficult to distinguish from iron deficiency ; older leaves tend to be more affected than the younger.

Treatment.—Slight cases, as for iron. In serious cases, solid injection of manganese salts has given excellent results, e.g. very valuable cherry orchards which had ceased growth and cropping and were sentenced for grubbing by the growers have been restored to growth and cropping within twelve months at small cost. Manganese sprays are also useful, and being much less toxic than iron can be recommended more confidently.

Magnesium.—Magnesium cannot be called a trace element since it is present in comparatively large quantities both in soils and plants, but it is convenient to consider it with trace elements as it is not usual to include magnesium in fertilizers.

By growing plants experimentally with insufficient supplies of magnesium, the symptoms characteristic of this deficiency have been established for many crops. The symptoms thus found by experiment to be characteristic of magnesium deficiency in fruit have been reported from many areas of this country, and from Canada and America ; the economic effect of this deficiency is being investigated.

As the magnesium uptake of plants is comparatively large, as no magnesium is supplied by most artificial manures and only moderate amounts by organic manures, and as the soil loses magnesium by leaching, a real deficiency of this element seems likely, particularly in areas of heavy rainfall. Magnesium deficiency symptoms often appear when heavy and long continued potash dressings have been given.

Symptoms.—These vary from crop to crop, and can easily be confused with symptoms of other deficiencies ; growers should consult an expert before concluding from symptoms alone that they have this deficiency and undertaking expensive remedies.

Treatment.—If the symptoms appear after potash manuring, the point should be considered whether potash can safely be withheld. Soil treatments are recommended rather than injections or sprays, viz. the use of magnesian limestone when there is no danger of over-liming, otherwise magnesium sulphate (Epsom salts). In any case, recovery is slow, and it cannot yet be claimed that this deficiency can be controlled as satisfactorily as those of iron and manganese.

Summary.—Cases of poor performance or disease in fruit which were formerly unexplained, are now known to be due to deficiencies of trace elements ; such deficiencies can now be diagnosed and successful methods of treatment are known.

The attention of growers in this country is drawn to deficiencies of iron, manganese and magnesium ; deficiencies of other elements affect fruit elsewhere, but their importance in this country is not yet established.

Much can be done by intelligent management to avoid deficiencies : in suspected cases the advice of an expert should be sought, for a diagnosis and details of curative measures.

* The monographs mentioned above, with coloured illustrations, should be consulted for full descriptions of symptoms of various deficiencies.

"WHY DOES MY SPRAY-PROGRAMME FOR SCAB BREAK DOWN?"*

By M. H. MOORE

DURING the past few years some fruitgrowers who usually are not unduly troubled by their Scab-control programme on apples have been wondering why things have once or twice gone wrong, and there is a tendency to blame whatever fungicide they happen to be using and to try something else. Before doing this, however, it might be profitable to look back into the records to see if the weather or some other interruption interfered to any great extent with the timing of the various sprays. Long intervals between sprays, and especially the earlier ones, are more frequently the cause of disappointment than a poor fungicide, especially where the Spray Calendar's recommendations as to choice of fungicide have been followed.

Weather conditions around blossom-time and labour shortage on most farms have together been responsible for some recent difficulties, particularly in 1941 and 1943. Last year (1943) the blossoms opened very rapidly and many growers were unable to get round a second time before blossom (at pink-bud). During blossom-time rain set in with high wind, and the petal-fall spray was consequently delayed, as in 1941. It so happened that although the season was early the fungus was a little later than usual in ripening its main batch of spores, and many of these were being distributed after the blossoms had opened, just in time for the onset of rain. The petal-fall spray, therefore, became of more than usual importance, but it was delayed. Such circumstances as these were the subject of comment in an article in *The Fruit-grower* of 13th April, 1939, when they were emphasized as the chief unavoidable cause of failure of the spray programme.

Since that time, experiments on the effect of spraying whilst the trees are in full bloom enable the following advice to be offered to growers as something to aim at even if circumstances make it difficult to put into practice.

1. Plan to allow no more than two weeks' interval between consecutive sprayings for Scab at green-cluster, pink-bud, and petal-fall. Accurate timing at these periods may render later sprayings unnecessary and so solve the mid-summer sulphur-damage problem, though there may still be Red Spider to deal with. If pink-bud follows soon after green-cluster—say, about a week—because of the weather, do not omit the pink-bud spray, but go quickly round the most Scab-susceptible kinds with lime-sulphur alone at 1 or 1½ per cent. Following the 2½ per cent. with or without lead arsenate at green-cluster, the weaker spray will do no harm and will freshen up the deposit for the blossom period.

2. Not more than two weeks after the spraying at pink-bud, have all the tackle ready to start the petal-fall application at the first opportunity, *even if there is still a good sprinkling of bloom about.* We have sprayed trees in full bloom with 1 per cent. lime-sulphur or with colloidal sulphur at 6 lb. per 100 gallons without interfering for more than an hour or so with the activity of the bees, and have picked a full crop, so that spraying after the trees have had a fortnight in which to set a crop should be quite safe in all normal circumstances. It is, of course, best to start with the most forward varieties where it is convenient to do so. Where frost has killed the early blossoms, the later ones will survive 1 per cent. lime-sulphur or colloidal sulphur in conditions favourable for pollination. With very cold wind, however, the decision is not so easy, and each grower must then decide for himself whether to accept a high risk of severe Scab or to gamble on a much smaller risk to his late blossoms. The risk can be even more reduced by using colloidal sulphur instead of lime-sulphur. It *is* certain that if Scab really gets going among the tiny fruitlets the crop will be very much reduced, for fruitlets attacked at that stage will drop. Lead arsenate should not be added to the 1 per cent. lime-sulphur because of the risk of arsenical damage and the danger to bees working late blooms; lead arsenate should have done any job demanded of it in the green-cluster spray when, with 2½ per cent. lime-sulphur, the combination is recommended. Nicotine should be added to the petal-fall spray for Sawfly even if there are still some blooms present; prompt application is beneficial against Sawfly as well as Scab, and the Scab-control programme cannot wait. If Sawflies attack the late blooms after the petal-fall spray has been put on, a nicotine and wetter spray a week later may be desirable on very susceptible varieties (e.g. Worcester).† Soap is perhaps best avoided as it might conflict with spray-deposit already present, particularly if lead arsenate has been used at pink-bud, though the risk is small after an interval of three weeks.

It must be borne in mind that the necessity for these adjustments in the normal programme

* Reprinted from *The Fruit-Grower*, **97**, 20th April, 1944, 295-6.

† This recommendation has the support of Dr. A. M. Massee.

will not frequently arise. They are suggested as a result of recent experience and can be adopted when expedient. The blossom period should not be permitted to interfere with Scab-control treatment more than it need. With present labour difficulties, powerful spray-machinery capable of dealing with large acreages at speed is a distinct asset, and should be turned to good account in off-setting shortage of man-power and thus helping to solve the very important problem of timing the sprays correctly. It is more profitable to give spraying pride of place in April and May than to put it off, even for a few days, hoping to catch up later, when the damage is so often already done. Some growers meet the timing difficulty by using copper-lime dust to tide over a long blossom period. Although there is much to be said against wet copper sprays on apples because of the damage they cause, there is no doubt that copper dusts have satisfied many growers, and, like sulphur dusts, can thus be regarded as a very useful standby. They appear to suffer no condemnation from bee-keepers.

Summary.—Failure to control Apple Scab is discussed in relation to the timing of sprays, and improvements are suggested.

NORFOLK GIANT—A RELIABLE RASPBERRY FOR THE PRESENT DAY

By R. V. HARRIS

A " New Deal " for Raspberry Growers.—As recently announced in the press, the Ministry of Agriculture is prepared to undertake this year the inspection of stocks of *Norfolk Giant* raspberry " in respect of purity and freedom from disease ". This is of fundamental import to the raspberry growing industry, and in the present writer's opinion introduces a new era in raspberry cultivation in this country, comparable in every respect to the impact of " Certified Seed " on the potato industry. At long last the fruitgrower will be able to plant up his new acreage with cane, not chance selected possibly from diseased plantations that have failed and are about to be grubbed, but with a guaranteed bill of good health, potential vigour and productivity. The present limitation of the Scheme to this single variety may be taken to imply its possession of distinctive features enabling the easy maintenance of disease-free cane.

By courtesy of Mr. P. E. Cross, Horticultural Superintendent to the Norfolk County Council, the present writer recently toured the area from which Norfolk Giant originated, and in which it is still widely and almost exclusively cultivated. Plantations of ten to twelve years, still profitably cropping, were commonly to be seen, and the younger plantations were outstandingly uniform in health and vigour. This is remarkable since Norfolk Giant was cultivated anonymously in an East Norfolk district for some years prior to its general introduction to the industry in 1922, and is therefore older than the now generally decrepit Lloyd George. It is interesting to consider why it should thus be in a favourable position to supplant and survive this famous and once apparently indomitable variety.

Scientific investigations have shown that the " survival value " of any good raspberry variety (as of the potato and other vegetatively propagated crops) depends on its reactions to *virus diseases*, of which in the raspberry there are two main classes, Mosaic and Leaf Curl diseases. It is a dangerous feature of these diseases that the cane progeny of any infected plant are themselves inevitably and incurably virus-infected, so that, in addition to their natural spread from plant to plant these diseases are also multiplied and spread in the normal process of vegetative propagation unless all diseased parent plants are early recognized and systematically destroyed. Now Norfolk Giant has the valuable and distinctive feature of being highly expressive (or sensitive) of both Mosaic and Leaf Curl diseases. Infected stools thus invariably develop a distinct range of recognizable leaf symptoms (see Plate) later coupled with a generally dwarfed and degenerate appearance. Lloyd George, and many other so-called " carrier " varieties on the other hand, are incompletely expressive and more tolerant of these viruses, so that virus-infected stools cannot always be visually distinguished from normal (healthy) stools, and it is therefore impossible completely to eradicate the former by field inspection alone. As no raspberry variety has yet promised an absolute and invariable tolerance of virus, there is thus no simple means of avoiding the ultimate (if slow) " degeneration " of such varieties.

Norfolk Giant also has a marked degree of natural resistance to infection by the Mosaic Diseases, and this has doubtless contributed greatly to the remarkably persistent health of English plantations of this variety. However, although for this reason Mosaic Diseases have as yet made comparatively small inroads in current stocks of Norfolk Giant, a small but growing proportion of infected stocks are to be seen in most plantations to-day, and this is appreciably higher where it has been raised alongside such highly infected varieties as Red Cross or Lloyd George.

Such a mounting increase of Mosaic diseases in Norfolk Giant must therefore be checked without delay if the variety is to be preserved. This, as we have seen, can easily be done and the Scheme for an official certification of cane for (among other things) a low maximum of Mosaic diseases has most opportunely provided the necessary encouragement and impetus. All growers with young healthy plantations of Norfolk Giant are therefore strongly recommended to enter them for certification this year. An initial failure to satisfy the standards of certification in the first year should not unduly discourage an entrant, because he will then at least know the worst about his stock and can plant up eligible new areas for future cane propagation with stock re-selected from his original plantations or with new certified cane from outside sources.

Another basic requirement for the health of Norfolk Giant plantations is their freedom from any trace of the very dangerous Leaf Curl virus disease. This disease is now rampant throughout the Strathmore raspberry growing area of Angus and Perthshire,* but has not yet been identified south

Leaves from two first-year canes of Norfolk Giant showing the range of Mosaic Disease symptoms.

of the Border. In the Strathmore area, Norfolk Giant was introduced recently to replace the generally deteriorating local stocks of Lloyd George, and it is now suspected on strong evidence that Lloyd George " carries " Leaf Curl virus, and is thus infecting the Norfolk Giant acreage. In attempting to eradicate Leaf Curl, therefore, it is essential to eliminate such dangerous Lloyd George stocks and to replace these and suspect or infected stocks of Norfolk Giant by stocks known to be absolutely free from Leaf Curl and healthy in other respects.† Until sources of such cane are identified or established under some official system of certification, the normal demand for English certified Norfolk Giant canes is thereby likely to be increased, if only to provide reliable basic stocks for local propagation. An illustrated description of Leaf Curl has recently appeared in the horticultural press and can also be found in Advisory Leaflet No. 55 of the Scottish Department of Agriculture and in the *Annual Report East Malling Research Station, 1942* (1943), p. 48. Growers in England are urged to scrutinize their plantations for signs of this disease and if anyone suspects an outbreak he should

* See Harris, Bryce and Foister, *Ann. Rept. East Malling Res. Sta. 1942* (1943), pp. 48-50.

† At the instance of the Agricultural Research Council, the present writer and Dr. C. H. Cadman (c/o Botany Department, University College, Dundee) have this year started an intensive research investigation of raspberry diseases in Scotland with special reference to the control of Leaf Curl and Mosaic diseases.

inform his Provincial Advisory Mycologist, County Horticultural Officer or War Agricultural Executive Committee, or report direct to the Plant Pathology Laboratory, of the Ministry of Agriculture, Milton Road, Harpenden, Herts.

The Pre-requisites for Certification.—The basic requirement for starting to propagate reliable and healthy planting cane of Norfolk Giant is a young plantation, if possible newly planted, but preferably not exceeding four years old, true to name, absolutely free from Leaf Curl disease, and with a low proportion only of stools showing Mosaic diseases. The canes should also be free from heavy infection with such fungus diseases as Cane Blight and Cane Spot. Some practice is necessary for the recognition of the symptoms of Mosaic diseases which are not, even in such an " exhibitionistic " variety as Norfolk Giant, easily distinguished at times from leaf discolorations due to other causes. Mosaic symptoms begin to appear from June onwards and reach their peak in September and early October. They vary in type (see Plate) and are best expressed when the canes are actively growing in moderate (not hot) summer and autumn temperatures. Direct sunlight or moisture on the leaves also tend to mask the symptoms.

Mosaic stools should, if practicable, be summarily removed (" rogued "), with all their roots and suckers, and destroyed. The first roguing is best made in July when, on a new plantation, diseased stools can easily be pulled by hand, and again in September ; as an extra precaution the two stools on either side of a " mosaic-stool " may also be removed. Growers with promising first year plantations would be well advised to consider turning at least part of them into a " cane-nursery " bed or " spawn-bed " (i.e. for cane propagation only).*

The adequate " mosaic roguing " of second year and older fruiting *plantations* becomes increasingly difficult and is probably impracticable except where the propagating area is small and the proportion of mosaic stools is found to be very low (not exceeding 3 per cent.). It certainly should not be attempted in plantations where the proportion exceeds 5 per cent. (one stool in twenty). In such cases cane may be re-selected for propagation by marking the mosaic stools in a selected length of row with stakes, later harvesting the canes at some distance from the stakes, and using this cane for planting up a new plantation or cane-nursery. If a stock turns out to have a very high proportion of mosaic disease a grower should consider replacing it (but not on the same site) with a new healthy (certified) stock, scrapping the old stock as soon as practicable.

Norfolk Giant and Other Varieties.—In thus recommending Norfolk Giant as a variety naturally reliable and well equipped for the replacement of current degenerate stocks of Lloyd George and other varieties, the present writer is far from intending an obituary notice of such varieties. He is well aware that in certain horticultural particulars Norfolk Giant makes poor comparison with Lloyd George and other varieties.

Exceptional strains of Lloyd George, retaining in marked degree the vigour and adaptability of the ancestral stock are in circulation, but although these are being developed with all possible speed, they are as yet available in very limited supplies. Recent experiments indicate that further re-introductions on the basis of re-selected and tested virus-free stock may be necessary for the full restoration of such " virus-tolerant " varieties. Such stocks must, however, be propagated under conditions of isolation ensuring them against infection by viruses which cannot be eradicated by field inspection and roguing.

Mention should also be made of the promising American variety *Newburgh*. This is a very highly virus-tolerant variety of which in this country there is at least one fine strain conspicuously free from Cane Blight disease, a trouble to which Newburgh is very prone.

Promising new seedling varieties are also in process of introduction, and it is unfortunate from some points of view that many of these resemble Lloyd George rather than Norfolk Giant in their reaction to virus diseases. But provided that such seedlings are not indiscriminately cultivated with Norfolk Giant and other " sensitives " to the detriment of the latter, there is every reason why their virus-tolerant qualities should be utilized to the full, bearing in mind, however, that if this tolerance decreases, or breaks down, very little if anything can be done about it. Meanwhile, it is encouraging that one at least of the promising seedlings raised by N. H. Grubb at East Malling has proved to be of the " virus sensitive " (Norfolk Giant) type, and it is hoped that future raspberry breeding work will deliberately aim at combining the improved fruit qualities of some of the virus-tolerant (" carrier ") varieties and seedlings with the valuable disease controlling qualities of a Norfolk Giant.

Summary.—Distinctive features of the Norfolk Giant raspberry, enabling the easy field maintenance of healthy planting stock, are described, and growers are advised to enter their young plantations for certification by the Ministry of Agriculture.

* Growers wishing to establish " cane nurseries " are advised to consult East Malling Research Station.

CATERPILLARS OF THE WINTER MOTH GROUP AND OF OTHER MOTHS

By A. M. MASSEE

MANY fruitgrowers fail to realize that the caterpillars of the Winter Moth group, together with several other species which occur on our fruit trees in the dormant season, in the egg or caterpillar state, are amongst the most important and harmful pests of our orchards at the present time. These caterpillars start to feed in the spring directly the fruit buds begin to open, and their feeding continues until the third week of June.

One or more species of these caterpillars may be found in any orchard in April and May, and their presence is a constant worry to the fruitgrower. The fact that caterpillars appear in most orchards even after a complete winter spraying programme has been carried out stresses the importance of these pests, and the necessity of eradicating them by spring washes. In neglected and derelict orchards various species of caterpillars and Apple Sucker are rightly regarded as the most important pests, and drastic spraying measures must be carried out to prevent them from defoliating the trees and destroying the fruit.

Many of these caterpillars are catholic in their taste, for they feed on apple, pear, plum, cherry, and nut indiscriminately. Indeed it may be said that the failure of many of the nut plats in Kent is largely due to defoliation by these caterpillars. Soft fruits also suffer very considerably, more particularly the gooseberry.

Amongst the twenty or more species associated with the defoliation of our fruit trees, the Winter Moth, March Moth, Mottled Umber, Early Moth, at least six species of Tortricids (these are the small, wriggling caterpillars which move backwards when touched ; they do not possess English names) and the Bud Moth, are probably the most important, at least before the flowering period. It should be noted that the Tortrix species hibernate on the trees in the form of a minute caterpillar, which is invariably tucked away under a canopy of silken webbing, which is attached to a bud or a spur. These hibernating caterpillars are extremely difficult to find on the trees, and they are so well covered by their silken canopy that a tar wash, petroleum, or D.N.C. does not affect them.

In addition to the species referred to above many others may be found on the fruit trees during the late winter and spring months. The list is too lengthy to enumerate fully, but it includes Figure of Eight Moth, Green Pug Moth, The Usher, December Moth, Northern Winter Moth, and occasionally the Lappet Moth. These and many others contribute towards the defoliation of our fruit trees during the months of April and May.

It is often suggested that a tar distillate wash, a straight petroleum or a D.N.C. applied at a strength of 8 or 10 per cent., will ensure a reasonable control of caterpillar if the wash is applied efficiently. Some control of caterpillar may be obtained by these winter washes, but it is very doubtful whether the application would be worth while for this pest alone.

As already mentioned a large number of species are involved in defoliating the trees, and unfortunately they do not all occur at the same season. The Winter Moth lays her eggs in late November, December, January and even February, while the Early Moth and March Moth oviposit in February and March, thus the egg-laying period extends throughout the winter. The Tortrix caterpillars are already in their silken webs. The fact that the egg-laying season of these harmful moths is extended over such a long period makes it impossible to apply a winter wash which will destroy all of them. It would seem that the best course to take is to delay winter washing until the middle of January at the earliest so that the peak period of egg laying of some of the more important species, i.e. Winter Moth, is passed before the winter wash is applied. The eggs which are laid after the application of the winter wash will, therefore, have to be dealt with when the caterpillars hatch out in the spring. Thus it will be seen that when control of caterpillar is contemplated by means of a winter wash the application should not be made in December or early January.

When the Tortrix caterpillars emerge from hibernation, and the eggs of the numerous other species start hatching in the latter part of March and in April, they invariably find their way to the developing fruit buds, and begin to feed on the unfolding leaflets. In mild weather they may be seen feeding on the outer leaflets of the buds, but if the weather turns cold and windy, they bore their way into the centre of the buds, where they enjoy considerable protection not only against adverse weather conditions but also from their natural enemies and poison sprays.

In order to obtain a reasonable control of these caterpillars it is essential to apply a lead arsenate spray early in the season. In practice it should be applied on apples along with the first pre-blossom lime-sulphur spray at the green cluster stage. Many growers have delayed adding the lead arsenate until the second pre-blossom or pink-bud stage. In seasons when caterpillar is very severe it may be

necessary to add lead arsenate to both pre-blossom sprays, but when only one application of lead arsenate is to be made, it should be mixed with the first lime-sulphur spray.

Lead arsenate paste should be used at the rate of 4 lb. to each 100 gallons, and powder at half that strength.

Caterpillar is the worst enemy of the cherry grower, and frequently some difficulty is experienced in applying the lead arsenate spray at the correct time, because the trees are about to come into flower at that time. Every effort should be made to apply the spray just before the flowers open, and if necessary a second application can be made at petal-fall. If the trees are growing in grass where sheep are grazing, it is advisable to graze the grass as short as possible just before spraying ; the sheep should then be removed elsewhere for a period of ten days or so.

A large number of species of caterpillar feed upon nut foliage, but doubtless the most important is the Winter Moth. This can be eradicated by spraying the bushes with lead arsenate about the middle of April. It cannot be emphasized too strongly that the caterpillars are very partial to the soft green nutlets, and every effort should be made to eradicate the caterpillars soon after they have hatched out, before they find their way to the developing fruitlets.

Summary.—A brief account is given of the species of caterpillars which infest cultivated fruits. The importance of controlling them by means of arsenical sprays before the blossom period is stressed.

INTENSIVE METHODS FOR THE PROPAGATION OF HOPS : A PLEA FOR SPECIAL HOP NURSERIES.

By F. H. BEARD

Introduction.—The urgent need of the hop industry at the present time, and one likely to remain for many years, is a supply of *healthy* material for the replacement of gardens which have had to be grubbed through the ravages of disease. The older method of propagation by " straps " cannot begin to meet the demand, both for the new varieties of which there are only limited acreages as yet, and for the established varieties such as the Fuggle and the Goldings which must be raised only from stock of known health. The old method, utilizing the bases of the past season's growth (straps), yields about 4,000-5,000 rooted plants from each acre ; thus an acre of established hops only provides material for the planting up of a further 5 acres each year of its life. The thorough roguing of large areas of hops is an impossibility, so that the need is for small carefully-selected plantings which by intensive methods of propagation will yield the maximum quantity of young plants, the production of " hops " being of secondary consideration, though crops will of necessity be produced. The greatest care must of course be taken that the parent hills in such a planting are disease-free.

Propagation Methods.—There appear to be two possible methods of intensive propagation :

1. **Layering.**—This requires no special equipment and can be used by the ordinary hop-grower. Layering is only the artificial production of runners which the hop plant produces freely when growing under natural conditions (i.e. hills not " dressed " or " pulled "). Whilst the hop plant will not form buds on its roots it will very readily produce roots from its stems. Layering has been used successfully at East Malling and by a few growers.

(*a*) *Method in layer bed.*—One or two bines are trained up each string to maintain the vigour of the hill, whilst a number of bines are laid along the surface of the soil and kept covered with soil as growth proceeds. Only the growing tips should be left uncovered, for if leaves are left exposed they are liable to be infected by Downy Mildew if the weather is damp. After about the end of July it is not worth continuing the earthing up, as the bines will not have time to change from bine to runner. After this time it is therefore important that the exposed tips of the layered bines should be protected from infection by Downy Mildew by sprayings with Bordeaux mixture. If a garden is planted specially for layering, a system of wirework should be used in which the layered bines can be laid along the rows, e.g., the " Butcher ", and are protected from disturbance by cultivations, etc. Where an existing garden of " Umbrella " wirework has to be used, the bines should be laid so that cultivation and spraying is possible in one direction. Gardens of the " Worcester " wirework system are not suitable for layering, as the hills are usually too close in the rows to allow of easy layering and if the layering is done across the alleys cultivation and spraying is impossible. Hills planted for layering should be at least 6 ft. or 7 ft. apart in the rows to allow of adequate room for laying the bines. Young plantings should be allowed to get well established before layering is begun.

(*b*) *Method in the Nursery.*—During the winter following layering the layers are unearthed and cut into suitable lengths each containing at least one node. The cuttings are then planted in grips*

* Narrow V-shaped furrows made with a spade.

taken out with a spade and made firm by treading. The top of the cutting should be just below the ground level to prevent possible drying out by cold winds or lifting by frost. If, in exceptionally severe weather, the cuttings become lifted, they should be made firm again as soon as possible. The number of cuttings obtained will naturally vary according to the vigour of the variety, but at least 50 should be obtainable from an established parent plant, thus giving about 50,000 cuttings or 40,000 rooted plants per acre. The sets obtained from layer cuttings (or natural runners) are smaller than those from " straps ", but they are nice and compact and quite large enough for planting out in their permanent positions. Whether the material planted in the nursery is " strap " cuttings or layer cuttings it is essential that some support be provided for the bines so that effective spraying can be carried out against Downy Mildew, Aphis and Red Spider. Nothing elaborate or expensive is needed. At East Malling we use chestnut stakes at 15 ft. intervals, running a cheap wire along at about 4 ft. from the ground. Just above ground level a double strand of coir yarn is run, and between this string and the wire a continuous single string is run in a V pattern. Where pea boughs are readily obtainable they make satisfactory supports and are used by some set raisers.

It is most important that the nursery should be situated on " clean " land, otherwise there is grave risk that healthy cuttings may become infected with Verticillium Wilt. (A case of this type has actually been recorded.) Freshly broken pasture or long ley would seem to be the ideal site from the disease aspect, though wireworms might be a serious trouble. Land recently occupied by hops, potatoes or raspberries should be avoided. It is desirable that hop propagation should be carried out as far as possible from existing hop gardens so as to reduce the risk of infection.

2. Softwood Cuttings.—Bailey (1939) carried out preliminary experiments to see if hops could be propagated by means of softwood cuttings.

(*a*) *Source of material.*—Bailey found that young surplus shoots taken in the spring when a few inches tall (" asparagus stage ") would root readily without the aid of a growth substance. Young laterals from the lower part of the bine which are normally discarded in the operation of " stripping " could be rooted with the aid of a growth substance. Bailey's experiments were carried out on certain of the new varieties, and owing to war conditions it has not yet been possible to ascertain definitely whether Fuggle and Goldings will behave in a similar manner.

(*b*) *Equipment needed.*—The softwood cuttings require to be planted in cold frames and transplanted or potted on when rooted. In the case of lateral cuttings they need to be grown on for a second season in a nursery before planting in the hop garden, but the " asparagus " shoots will give plants which though small are fit for setting out in their permanent positions at the end of the first season. The full technique has been published by Bailey, so need not be given here.

3. Comparison of the Two Methods of Intensive Propagation.—*Layering* requires no special equipment and can therefore be carried out by the hop grower with his existing labour. However, two seasons are required to produce plants fit for their permanent positions. Layering would seem the most suitable method for those varieties which do not produce many shoots from the crown in the spring.

Softwood cuttings require the equipment and labour of the nurseryman and plant propagator and this method of propagation is more suitable for a specialist set-raiser rather than the hop grower. With the " asparagus " shoot type of cutting, rooted plants fit for sale can be obtained in one season compared with two seasons by layering. This method appears to be most suitable for varieties which produce an abundance of shoots from their crowns in the spring. The use of lateral cuttings seems to be economic only in special cases such as the rapid propagation of a new variety from a nucleus of a very few hills.

4. Improving the " Take " in the Nursery.—At East Malling we estimate to produce about 75 saleable plants from each 100 strap or runner cuttings planted, but the percentage varies considerably according to season and variety, being sometimes as high as 90 per cent. or as low as 50 per cent. When cuttings are planted singly in pots under greenhouse conditions (for experimental purposes) the " take " is always very good. Investigations have been started to ascertain if it is possible to improve the " take " under field conditions. An experiment in which strap-cuttings were treated with a growth substance prior to planting gave negative results (see p. 68 of this Report). An experiment is now being carried out to ascertain the seasonal and varietal variation in the " take ". This information will be helpful in planning further trials designed to ascertain if the " take " can be improved. It may be that certain soil types or environmental conditions will give better results than others. It has not yet been possible to ascertain if layer-cuttings give a " take " equal to that of strap-cuttings, but trials have shown that natural runner-cuttings give results equally as good as those of strap-cuttings though the sets are rather smaller. Runners are not normally used for propagation in this country, though they are the usual method in U.S.A. However, in some seasons a fair quantity is produced and these should certainly be made use of where it is desired to obtain the maximum increase in stock.

Summary.—The need for intensive methods of propagation from relatively small areas of parent hop plants is stressed. Layering and the use of softwood cuttings are mentioned as methods. The technique of layering is given in detail, together with reference to a previously published report on the use of softwood cuttings. The relative merits of the two methods are discussed. The need for improvement in the normal " take " of cuttings in the nursery is mentioned.

Reference

Bailey, C. R. (1939). " Some preliminary experiments in the use of root-initiating substances in hop propagation." *J. S.-E. Agric. Coll.*, **44**, 47-53.

AMENDMENTS TO SPRAY CALENDAR, 1942 EDITION

When the 1942 Spray Calendar was issued we pointed out that it was printed on unvarnished paper so that " such alterations or additions as may from time to time become necessary can easily be made " It has already been necessary to make one addition, the treatment for Cane Spot on raspberries, and this was done by means of a printed stick-on slip. It now becomes necessary to make a number of small alterations and we are leaving it to each individual to write in the correction on his calendar.

In view of the revised naming of the bud stages, recently published by the Ministry of Agriculture in the form of coloured charts, the words " Green Bud " should be altered to " Green Cluster (Green Bud) " in the centre caption to sketches in left-hand notes column and under Petroleum Oil in right-hand notes column.

Other changes are set out in tabular form as follows :—

Reference.	As at présent.	New Version.
Notes, left-hand column. Key. bottom of column.	 D Derris.‡ CS Colloidal Sulphur§ (i.e. up to one per cent.)	 add Lonchocarpus. add Dispersible Sulphur (i.e. one per cent. or less).
Apple, 2nd week June	CS Scab	CS Scab, Mildew.
Pear, 4th week March	L 2½ gal.	L 2½ gal. Scab, Blister Mite.
Hops, last three weeks August		D Dust. Strig Maggot. ↓
Gooseberry, 4th week April	L ¾ gal.	CS (see Note 1).
Loganberry, Blackberry, January and February		DNC 8 gal. Capsid ↓ Aphis
Strawberry, July and first three weeks August	N (vapour) Aphis	Transfer to end of June

Note 1.

Weak lime-sulphur with lead arsenate is now recognized as a very dangerous spray, it is important therefore not to mix together the L ¾ and A 2 lb. indicated in the calendar for **Gooseberries.** For this reason colloidal sulphur is preferable at this stage.

Note 2.

In an early season the June lead arsenate on **Apples** for Codling control should be applied by the middle of the month instead of during the last week. This spray can then be put on with the spray for Scab, etc., in the second week of June, but for the same reason that is given in Note 1 CS and *not* LS should be the fungicide used.

H.B.S.M.

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